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## ANECDOTES AND OTHER NOTES ON METALS[1]


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Gold, the glamor metal of them all, is too regal to have anecdotes in its history. Its production by transmutation, the dream of the alchemists, did, however, get many of them into trouble as imposters.

Metals were redefined by the industrialists as "the connective tissue of mechanization." In this age of aeronautics the ideal "tissue" has concern for excess baggage, so, in consequence, seeks the maximum tensile stoutness associated with the minimum weight. Such specifications open the door to metals of recent release from nature's storehouse; aluminum and magnesium.

### ECONOMIC EVOLUTION OF A METAL

Aluminum's emergence above the horizon of unclaimed metals reads like a Horatio Alger story of economic success. Wöhler's first potassium-reduction of its chloride, put in the language of the money mart, rated aluminum at $150 per pound; DeVille, twenty-seven years later, by his use of sodium-reduction was able to mark the price tag $15 per pound; Castner, thirty-two years after DeVille, was happy to report that aluminum from his plant would cost only $4 per pound due to a greatly improved method of preparing the metal, sodium. Castner's market superiority was of short duration for, but three years later, Charles M. Hall patented his electrolytic method which marketed the metal at but one dollar per pound. Most readers know that, as of this year, sixty odd years after that patent, mass production places this, one time "rare" metal, in price competition with

[1] "Dramatic Moments in the History of Science," SCHOOL SCIENCE AND MATHEMATICS, 49, pp. 73–706 (1949).

so-called "plebian" iron marked in cents rather than with the dollar sign.

## A Spark in Mental Tinder

Remarks made by teachers do, on occasion, start *mental* chain reactions for students. Such seems to have initiated Hall's project which eventuated in the patent. Told in the words[2] of Hall's Oberlin chemistry teacher, Professor Jewett, "In the laboratory one day . . . I said that if any one should invent a process by which aluminum could be made on a commercial scale, not only would he be a benefactor to the world but would also be able to lay up for himself a great fortune. Turning to a classmate, Charles Hall said, "I am going for that metal." And he went for it.

"He tried various methods in vain, and finally turned his mind to the idea that perhaps electricity would help get the metal out of its ores. . . .

"Soon after . . . he graduated . . . he took the apparatus (he had devised with Professor Jewett's help) to his own home. . . . He arranged a little laboratory in the shed, continued his investigations and reported to me frequently.

"About six months later he came over to my office one morning, and holding out his hollowed hand, said, 'Professor, I've got it!' There in the palm of his hand lay a dozen little globules of aluminum, the first ever to be made by the electrolytic process in this country."[3]

## Aluminum for Coins, Francs

Charles Hall's French contemporary and simultaneous discoverer of the electrolytic reduction of aluminum ores, Paul Heroult, had his first memorable experience with aluminum when he and a friend, who later became his partner, had to pawn a stick of aluminum for a few francs to relieve their flat pocket books. The aluminum bar was valued highly by his friend's family because it was a personal souvenir from Saint Claire DeVille.

In Heroult's own words,[4] "We handed the bar to the pawn broker who examined it and asked, 'What is that—bar silver?'

"We answered, 'Better than that, that is aluminum.'

" 'Aluminum?' was his response, 'What is aluminum?'

"Then after he had hefted it by his hand he asked, 'Why! Is that hollow?'

"Our answer was, 'No, that's aluminum and is worth 120 francs per kilo.'

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[2] Holmes, Harry N. "Story of Aluminum." *Jour. Chem. Educ.* 7, 235 (Feb., 1930).

[3] These original globules—the "crown jewels" of the aluminum industry are now carefully preserved in an aluminum "jewel case" in the offices of the Aluminum Company of America.

[4] *Ind. & Eng. Chem.* 3, 149 (1911).

"After some thought he replied, 'Well, I'll give you two francs for it.'

"That was better than nothing so we took the money with the firm determination of buying it back—which we never did. Maybe that was one of the reasons why, later on, I had to make good and replace it."

Heroult's announcement of his successful electro-reduction of aluminum from its ores post-dated Hall's by only about three weeks. Some seventeen years after the announcement of their processes were made, patent rights were finally assured to Hall for America and to Heroult for Europe.

## Aluminum Transmuted

Aluminum also made newspaper headlines, later, in Heroult's native France. This time it, under the impact of alpha particles from polonium, became one of the first artificially induced radio-active elements. The product of this transmutation was radio-active phosphorus. That took place in 1934 in the laboratory of the Institute of Radium in Paris. Its occurrence was induced under the supervision of Irene Joliot, daughter of the Curies, and her husband, Frederick Joliot. Thus aluminum got into one of the first achieved transmutations which the alchemists hoped to make possible by the use of their philosopher's stone (if they could only find it). The final stable product of this, aluminum's change, was not gold, as the alchemists desired, but an isotope of silicon.

## It Might Have Been

Metals, like men, sometimes fail to achieve industrial standing by scarcely more than a "hair's breadth." The evolution of industrial aluminum's economic reduction, previously described, spots a brief appearance of the metal, sodium, as a case in point. Wöhler reduced the first compound of aluminum by use of metallic potassium; DeVille reasoned that since sodium is much more plentiful it should become a more economical reducer. He, by its use, reduced aluminum metal's cost by ten fold. In 1886 Hamilton Y. Castner, a young student in the School of Mines at Columbia University, invented a new process for the manufacture of sodium which lowered aluminum's cost by about 75% below DeVille's figure. "A large plant was immediately erected to prepare the metal on a commercial scale using Castner's process"[5] but these plants were never used to magnify the aluminum industry because Hall's electrolytic process was able to under-cut the sodium reduction cost by 75%. Had Hall been delayed a few

[5] Chandler, Charles F. *Ind. & Eng. Chem.* 3, 145 (1911).

more years, sodium metal might have become an article of commerce upon large quantity scale. "It might have been."

### Laboratory Lilt

'Tis true that the first five letters of laboratory spell labor and for the most part that word well describes what goes on within those halls. However, there are days of high adventure as well as dull drudgery for the experimenters.

Sir Humphrey Davy tells of his study of electro-reduction of potash as follows:[6] "Small pieces of pure potash . . . were placed upon an insulated disc of platina connected with the negative side of the battery . . . and a platina wire . . . (positive) was brought in contact with the upper surface of the alkali. . . . A vivid action was soon observed to take place . . . at the lower or negative surface . . . small globules having high metallic lustre, and . . . similar to quick silver, appeared. . . . These globules, numerous experiments soon shewed to be the substance I was in search of."

But while Sir Humphrey was looking at the "small globules" a relative, Edmund Davy, was watching the experimenter. That person's behavior he reports as follows:[7] "When he saw the minute globules of potassium burst through the crust of potash and take fire as they entered the atmosphere, he could not contain his joy—he actually bounced about the room in ecstatic delight; some time was required for him to compose himself sufficiently to continue the experiment."

### Accessory before the Fact

It is pretty generally known, by physical scientists, that radium metal shared some of the limelight of publicity received by the two Nobel prize awards to its discoverers, the Curies. The Nobel prize, in 1932, to an American, Irving Langmuir, for his work on "surface chemistry" is not generally known to be partially creditable to a behind the scenes participant, the metal, tungsten. It was a research tool in the hands of its skillful user in securing the findings that challenged the attention of the Nobel awards committee. A census[8] of the research papers for results leading to: gas filled incandescent lamps, the atomic hydrogen torch, the electron tubes of radio or television indicates tungsten used almost universally in that research. Doctor Langmuir's comment[9] is "The use of the tungsten filament presented particular advantages for (it) could be heated in high vacuum to

[6] Works of Humphrey Davy, Smith Elder & Co., Cornhill, London. 5, 60–61 (1840).

[7] *Ibid.*, 1, 109 (1840).

[8] The frequency of Dr. Langmuir's use of tungsten is roughly indicated by seventy odd specific references to it in his recently published *Phenomena, Atoms and Molecules*. Philosophical Library, N. Y. (1950).

[9] Langmuir, Irving. *Phenomena, Atoms and Molecules*. Philosophical Library, N. Y. (1950).

temperatures of over 3000°K. so that all impurities could be readily distilled out of the filament. The ease and accuracy with which any desired temperature could be produced and measured was also important." And again he says,[10] "Because (tungsten filaments melt at temperatures more than 1500° higher than platinum) it had seemed to me that tungsten furnished a tool of particular value for the scientific study of phenomena in gases at high temperatures." In legal parlance, an "accessory before the fact" receives attention from the judge at the same time the principal gets his sentence; Doctor Langmuir gets the prize but his "accessory" should get some credit also.

### When Miners Prospect and Exploit the Sea

When "ships go down to sea" it is usual to expect that they may return with cargoes of fish or whale blubber as their tribute from the realm of Neptune. When metallurgists "go down to sea"—well, that's a bit aside from the expected! Traditionally metals have been landbound either in native form or as constituents of ores which are insoluble in water.

So it is a bit sensational, as well as historical, to read,[11] "On Tuesday, January 21, 1941 (the Dow Chemical Company's) great new plant at Freeport, Texas produced the first commercial ingot of any metal to be taken from sea water at any time in the history of the world!" The novelty of this announcement was not that a metal was being extracted from water. "For years (Dow's) had been mining Michigan brine for magnesium as well as for bromine and chlorine." The innovation was that the source this time was *sea* water rather than *well* water.

The Dows had previously exploited Father Neptune's resources, in 1930, by successfully extracting bromine from raw ocean water at Kure Beach, North Carolina. But, superficially, there doesn't seem to be such a stretch of credulity expected when liquids are taken from water sources as that of bringing forth metals.

It is interesting to note that the choice of Freeport as the place for the extraction plant was, to a large extent, based upon a "trinity of basic inorganic chemical raw materials—salt, sulfur and lime." The salt, with its constituent magnesium, came from the sea; the lime from oyster shells dredged from the bottom of the Galveston Bay and the sulfur from the Frasch wells which are plentiful in Texas and neighboring Louisiana.

In chemical language, lime, made by heating the shells, was used to precipitate the magnesium from the sea water; this magnesia lime precipitate was then transformed into a chloride (similar to table

[10] *Ibid.*, page 104.

[11] Kirkpatrick, S. D., *Chem. & Met. Eng.* 48, 130–133 (Nov. 1941).

salt) by the use of hydrochloric acid and the magnesium chloride, in turn, was deprived of its magnesium by electro-reduction.

Successful was it? Report has it that by 1941's year end production was at the rate of 54,000,000 pounds; about seven times the production of 1940 and over fifty times that of seven years previous to that. This upsurge in production dropped the price from five dollars per pound in 1915 to twenty-two and one half cents per pound in 1941.

## Some Impulses Are Fruitful

Winkler, in 1885, was asked to make a thorough quantitative analysis of a mineral called argyrodite. He found the elements in it that had been previously reported but he "invariably came out seven per cent too low. He concluded the ore must contain an unknown element."[12] His first attempt to isolate it assumed that it belonged, analytically, with arsenic, antimony and tin. He was able to remove the first two by traditional methods of separation but attempts to get the new element from the filtrate, after arsenic and antimony's removal, gave no precipitate other than sulfur. He worked four months in a vain endeavor to bring the elusive element into view.

"On February 6, 1886, he filtered off the precipitated sulfur,[12] as he had done so many times before and, reckless with discouragement poured into the clear filtrate a large quantity of hydrochloric acid. To his delight a heavy, flaky white precipitate immediately appeared. This substance (was) the sulfide of the new element." Thus the first isolation of a new element was accomplished and later identified and named germanium. So the third, of three elements Mendeljeff had previously postulated and described to fill gaps in his periodic chart of the elements, had been isolated by what might be called a rash act committed in semi-desperation. The agreement of germanium's properties with those proposed by Mendeljeff added substantially to that Russian's prestige and esteem of his fellow chemists.

We may talk of metals as products of skillful technology; as illustrative of sub-atomic structures that help to rationalize many of their unique qualities or in terms of stock-piling in anticipation of emergencies. Such attention is, very commonly, considered practical, down-to-earth, eminently worth while. On the other hand the stories in the preceding paragraphs might be labelled "metal gossip" by the cynically inclined. However, there is a common element in each of the incidents previously related—in every one there is a situation involving a human relationship. Their justification for the space they have used is: human relationships are significant from the standpoint of the teacher.

[12] Weeks, Elvira. *Discovery of the Elements.* (First Edit.) Mack Printing Co. pp. 225–227 (1933)

## FRANK B. WADE
(1875–1950)

Frank B. Wade was born in New Bedford, Mass., July 8, 1875, and died of a cerebral hemorrhage in his Indianapolis home the morning of October 3, 1950. His passage was sudden while in bed where he was confined with a cold. He had regained most of his physical and mental activity after a previous stroke some months before, as evidenced by his visit to Shortridge High School and attending a high school football game just a few days before his death. He is survived by his wife, Ethel N. Wade; two children, Miss Lucile, and Nicholas; and two grandchildren.

Mr. Wade was educated in the New Bedford, Mass., public schools and received his B.S. from Wesleyan University (Middletown, Conn.) in 1901. In 1938 Wesleyan granted him an honorary M.A., and in 1937 Wabash College (Crawfordsville, Ind.) awarded him an honorary D.Sc. degree. From 1901–1903 he was an instructor in chemistry at Lewis Institute, Chicago. In 1903 he became a member of the Shortridge High School (Indianapolis, Ind.) faculty and the head of the chemistry department in 1910, in which capacity he served until his retirement in June, 1949.

His hobby, the study, collection and shaping of diamonds and precious stones, led him into wide repute both in the United States and abroad as a gem expert, and his technical articles appeared from time to time in the "*Jeweler's Circular*," "*Mineralogist*," "*Rocks and Minerals*," "*The London Gemmologist*" and "*The Journal of Chemical Education*."

He also authored the following books: "*Foundations of Chemistry*," 1914 (with A. A. Blanchard); "*Diamonds—A Study of the Factors That Govern Their Value*," 1916; "*A Textbook of Precious Stones*," 1918; and "*The Teaching of Science and the Science Teacher*" (with Herbert Brownell).

Mr. Wade was a member of the Friends Church, Alpha Chi Sigma (professional chemical), Phi Beta Kappa (honorary scholastic), Psi Upsilon (social), the Masonic Order, and Scottish Rite. He was long active in the affairs of the Indiana section of the American Chemical Society, being twice the Section president. He was a fellow and past president of the Indiana Academy of Science, a past president of the Central Association of Science and Mathematics Teachers, and a fellow of the A.A.A.S.

On March 26, 1949, prior to Mr. Wade's retirement in June, a dinner and a program were sponsored in his honor by the American Chemical Society, Alpha Chi Sigma, the Central Association of Science and Mathematics Teachers, the Indiana Academy of Science,

and his many Shortridge High School friends. The dinner was held in the Shortridge High School cafeteria and the program in the school's Caleb Mills Hall. The speaker of the evening was Dr. R. Norris Shreve, head of the chemical engineering department, Purdue University, and he delivered an illustrated lecture on precious and semi-precious stones. At the dinner, Mr. Wade was presented a purse of over $1000.00, representing voluntary contributions and best wishes of his many friends among the various organizations which he had served so long.

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## A Tribute to Frank B. Wade

(Delivered before the October 12, 1950 monthly meeting of the Indiana section of the American Chemical Society)

Since I was called this morning and asked to say something about Mr. Wade, it was deemed advisable, on such short notice, to set down in words what is to be said, and read it. Besides, somehow, on an occasion such as this, to speak extemporaneously about Mr. Wade does not seem quite the thing.

He was as you know, a charter member, and a past president on two occasions, of the Indiana section of the American Chemical Society. A partial failure in health, dating back for a number of years, has kept him away from the Society and its affairs; so he may not be known at all by many of the current members, but all the older members have known him well, I am sure, and many people over the country and abroad know of him. You would be surprised, for instance, how casual mention of his name to miscellaneous gatherings of Indianapolis citizens brings response. It is said that a man cannot be a prophet in his own country, and while no one would label Mr. Wade as a prophet, the sense of the statement is refuted in his case, and a general recognition of him as an outstanding citizen in his own community, certainly indicates attributes of that indefinable quality which shakes out the mantle of greatness over the shoulders of the man.

A year and a half ago there was held here in the city a dinner in honor of Mr. Wade. It was a unique affair, and accounts of it, in the *Accelerator* and the city papers, emphasized his many honors and accomplishments, his long years of teaching, his reputation as a scientist and a gem expert, his publications, his society affiliations, and his long tenure of service to the American Chemical Society. These are all a matter of current review attending the sad event of his passing. I need not repeat them.

However, to me, these activities, save one, do not constitute those

elements which will keep the name of Mr. Wade alive in future years. Rather, they represent the various interests of a very alert and gregarious man and whatever they may have imprinted for the world to read, will lose the sharp edges of impression as time goes on and eventually give way to overwriting by makers of news who are current with their day.

To my mind, the outstanding qualities of Mr. Wade grew out of his long years of teaching, his live interest in it, and his love of it. He was a teacher in every sense of the word. His pedagogy was not dry textbook pages, one after another, but life itself, well draped and garnished with chemistry—always with chemistry, and always, always with the prime object of getting his students to think, to reason, to whet their wits for the years to come. Just as an occasional athlete appears born to a certain sport, Mr. Wade was a natural in the art of teaching.

In the classroom and out of it, he became a part of the lives of hundreds and hundreds of boys and girls, and I doubt that many of them have ever placed him within the limbo of discarded recollection. I would not be at all surprised but that in this audience there are some stuffy throats and moist eyes as we read these words about a man who wrought a monument to himself in the hearts of so many of his fellowmen through a continual spring of little services, day in, day out—little services shaping character, molding lives and helping, with each little chink of mortar, to build a stronger foundation for America.

Faces are forgotten, books and records become lost or destroyed, and even names carved on stone are no more permanent than that upon which they appear—but if a man has so served his fellows that he lives on in their souls, he attains indeed an everlasting life, and Destiny has touched him with greatness which need never be revived by oratory or a fanfare of trumpets. . . .

So he lived among us for a long time. He brought honor to the Society and the Shortridge High School where he taught so many years. He had his faults, just as you and I have faults, and thus proved himself as human as the rest of us, thereby adding to his stature in our eyes. His life was full and fruitful beyond the usual reaches of a citizen. And now he is gone and we do him homage in the full knowledge that one and all of us might have known him better.

It is shameful commentary on most of us, I suppose, and our national characteristic of rushing through life, that we merely water the roots of friendship sporadically instead of separating ourselves upon occasion from the whirl of events and sitting for restful hours with those among us who could mean so much more if we cultivated them intensively as a part of living.

"Around the corner I have a friend
In this great city which has no end;
Yet the days go by and weeks rush on,
And before I know it a year is gone.
And I never see my dear friend's face,
For life's a swift and terrible race.
He knows I love him just as well
As in the days when I rang his bell
And he rang mine. We were younger then.
We were not busy, tired men—
Tired of playing a busy game,
Tired of trying to make a name.
'Tomorrow,' I say, 'I'll call on Jim,
Just to show that I am thinking of him.'
But tomorrow comes and tomorrow goes,
And the distance between us grows and grows.
Around the corner! Yet miles away!
'Here's a telegram, sir.' 'Jim died today.'
And that's what we get and deserve in the end—
Around the corner, a departed friend."

JOHN R. KUEBLER

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## THE PACIFIC: A NEW FILM

The increasing strategical importance of the Pacific Ocean in international affairs is highlighted in a new, Technicolor educational motion picture, THE PACIFIC, released by Encyclopaedia Britannica Films.

Through the use of animated drawings in Technicolor the film tells the story of the development of the Pacific Ocean and its adjacent areas. The story begins 500 years ago when the Pacific area was unknown to Europeans and follows development of the area through the periods of exploration, settlement and commercial growth. In the concluding portion of the film the question of peace or war in the Pacific is examined and explained.

In the opinion of Richard Hartshorne, professor of geography at the University of Wisconsin and collaborator on the film, THE PACIFIC fills an educational gap caused by the tendency to place greater emphasis on other sections of the world than the Pacific, yet it now has become one of the world's most crucial areas.

THE PACIFIC is a one reel, full color film intended for use in junior and senior high school classes in history, geography and allied subjects, and by adult groups. It may be purchased for $90 from Encyclopaedia Britannica Films, Wilmette, Ill., or from regional offices in New York; Boston; Chicago; Birmingham, Michigan; Atlanta; Dallas; and Pasadena.

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*Liquid plastic* in a golden color is designed to apply to metal fixtures and objects in the household and impart to them the appearance of gold. Applied by brush or spray, the coating forms a non-porous, shiny, impenetrable, quick-drying, long-lasting, protective surface.

# POSTERS ON FRACTIONS

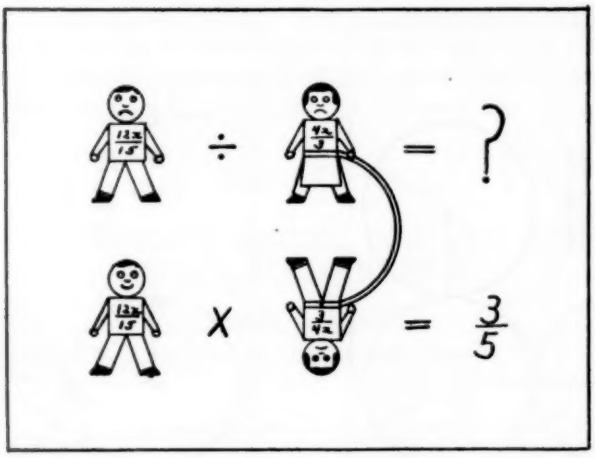
ETHEL L. GROVE, CHARLES E. SCOTT, AND EWART L. GROVE
*Cleveland, Ohio*

I. Construction

A. Materials

1. One rectangle of very stiff cardboard approximately $15'' \times 20''$.
2. Two rectangles of medium weight cardboard, same size.
3. One two-inch square of heavy white paper.
4. Sharp knife or razor blade.
5. Paper fastener, Scotch tape, glue, India ink, and pen.

B. Steps in Construction of Poster 1




Poster 1 on Fractions

1. On heavy cardboard draw the figure of a boy with a worried expression on upper left of poster and the same figure with a smile on lower left. Write $12x/15$ on each. (Figures are about $3'' \times 5''$.)
2. On lighter cardboard draw a similar figure of a girl and cut it out. Attach the paper apron with Scotch tape across its top edge. Write $4x/3$ on the shirt and $3/4x$ on the underside of the apron.
3. Determine the position of the girl in both situations and strike two concentric semicircles as shown in the illustration of Poster 1. Cut out the cardboard between the semicircles.
4. Through this slot attach the figure of the girl with a paper fastener under the apron to a small piece of cardboard back

of the model so that it will slide easily from one position to the other.

C. Steps in Construction of Poster 2

1. On the remaining cardboard rectangle draw three 7″ circles as shown in Figure 1, Poster 2.
2. From the remaining portion of the other rectangle cut three similar circles.
3. Cut one quarter from one of these and glue the remainder of it on the lower left circle as shown. Cut one third from another and glue the remainder of it on the upper right circle. Cut five twelfths from the third circle and glue that sector on the lower right circle. (These merely help to support the hinged sectors described later.)

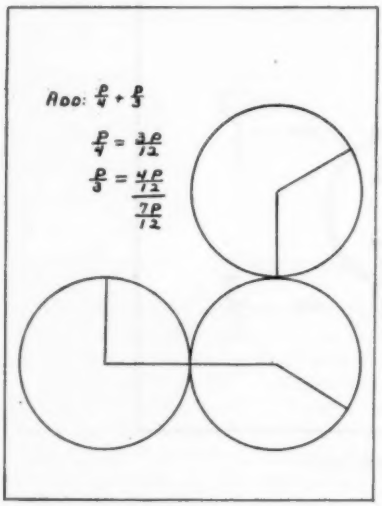



FIG. 1. Poster 2 on Fractions

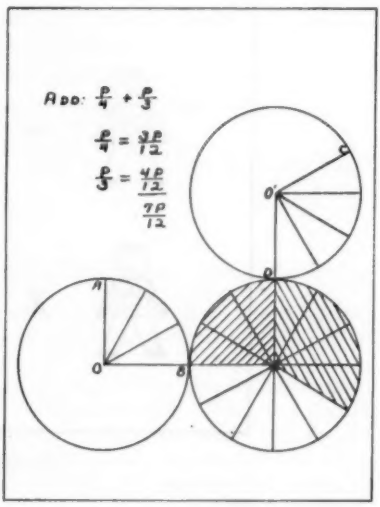



FIG. 2. Poster 2 on Fractions

4. Label the quarter removed in step 3 $P/4$ and letter it $AOB$. Label the third $P/3$ and letter it $CO'D$.
5. Make a hinge on $AOB$ by applying several strips of tape to both sides of the sector at $B$. Allow the tape to extend $\frac{3}{4}$″ beyond the cardboard, insert it through a slot between the two lower circles, and fasten it with tape on the back. Make a similar hinge on $CO'D$ at $D$.
6. Draw radii dividing the backs of the sectors, the areas under the sectors, and the entire third circle into twelfths. Shade the backs of the sectors.
7. Turn sector $AOB$ back over the third circle and turn $CO'D$ down over the third circle to show their equivalents in twelfths and their sum (Figure 2, Poster 2).

II. Use

A. Memory Aids

1. The average algebra student knows the reason for the least common denominator and needs only to be reminded of it. Therefore, put Poster 2 on the bulletin board and refer to it only when difficulties arise.
2. In most cases Poster 1 must be accompanied by an explanation of the reason for inversion. Then post it also in a place where the pupils may work with it and recall the explanation from time to time.

B. Teaching Aids

1. In groups having unusual difficulty with fractions Poster 2 may be used to teach the reasons for the least common denominator. Poster 1 may be used with such groups to fix the process in mind even if the reason is not clear.
2. By omitting the letters either poster may be used in junior high or general mathematics classes.

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## ALTERNATE MODEL FOR ARC AND ANGLE MEASUREMENT

ETHEL L. GROVE
*1814 Tuxedo Ave., Parma, Ohio*

I. Construction

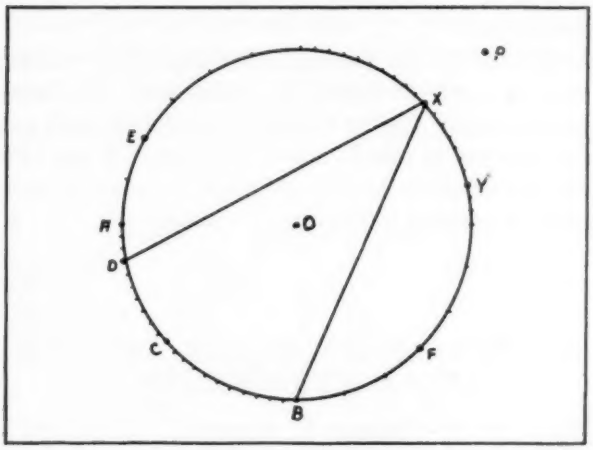
A. Materials

1. One rectangle of stiff cardboard approximately 15″×20″.
2. Approximately 24″ of smallest elastic cord available.
3. Protractor
4. Paper fasteners, India ink, and pen.

B. Steps in Construction

1. Draw a 12″ circle in the center of the cardboard and outline it in ink.
2. Mark off units of 5° or 6° on the circle in first and third quadrants. The remainder of the circle may be divided in larger units.
3. Put a paper fastener at center $O$, at points $X$ and $Y$ on the circle, and at $P$ outside the circle. Leave the fasteners loose enough to allow the elastic to slip under their heads.
4. Punch holes $A$ and $B$ slightly larger than the elastic at the end points of the third quadrant and holes $C$ and $D$ at the ends of diameters through $X$ and $Y$. (Make any other holes desired on the circle.)

5. Insert one end of the elastic through $B$ and knot it on the back of the model.
6. Stiffen the other end of the elastic with nail polish, varnish, or the metal tip from a shoe lace. Insert it through any other hole on the circle and stick a pin through it above the stiffening to keep it from pulling out.
7. Smaller models for individual use can be made as a construction problem. For these hat elastics with metal tips are ideal.




Arch and Angle Measurement

II. Use

A. Pupil Experimentation

1. Since observations on angle measurement must be much more systematic than on other topics, directed and recorded class investigation is more fruitful than bulletin board experiments.
   a. With the elastic through two given points, have different pupils read the angle measurement on the protractor and the corresponding arc measurement when the elastic is looped around $O$, $X$, $Y$, and $P$, and when crossed within the circle and looped around both $X$ and $Y$. (Best measurements will be obtained if the elastic is pulled back of the model to make slight tension, if the center of the protractor is held well to the outside of the paper fastener head, and if the legs of the paper fastener are perpendicular to the direction of the elastic.)
   b. Have a pupil record these readings on the board.

c. Move the free end of the elastic to other holes and repeat measurements until the pupils suggest from the data on the board the relationship between the arc and central angle, inscribed angle, angle formed by secants outside the circle, and angle formed by chords inside the circle, and angles inscribed in the same segment.

2. Then develop formal proofs for these suggestions.

B. Flash-card drill or review in which required parts related to one given measurement may be indicated on the model.

(The cardboard model described in the December issue may be used to demonstrate the relationships mentioned above, but it is not so well suited to pupil experimentation as this model.)

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## ABSOLUTE ANGULAR MEASUREMENT—A COMMENT

CECIL B. READ
*University of Wichita*

An article by Mr. Yudowitch in the October SCHOOL SCIENCE AND MATHEMATICS comments on the equation $\theta = s/r$ as an unique example in elementary physics of an equation whose truth is not invariant with units. Rather, one should hold that this is a special relation valid only when $\theta$ is expressed in radians. Only under this condition is it true that the ratio of one unit of length measured on an arc to one unit of length on the radius holds. If desired, one could use $\theta = ks/r$. Then, if radian measure be used, $k$ will equal unity; if degree measure be used $k$ will equal $180/\pi$.

It is true that degrees are dimensionless, but so also is pi. This does not permit us to drop pi from an equation, or to substitute some other value for it, merely because it is dimensionless. In the problem under discussion it is not valid to substitute some other value for unity, merely because unity is dimensionless.

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## ANOTHER COMMENT

ROBERT S. SHAW
*The College of the City of New York*

May I point out that a subtle error seems to have eluded one of the departmental editors, in the issue of October, 1950.

On page 522, in a note on angular measurement, a conclusion is drawn (last words of paragraph 2) from the assertion that "degrees are dimensionless." The final paragraph indicates that this is not a slip of the pen (or tongue, or typewriter).

The proper statement of the truth which the author is very usefully trying to express is . . . Angle is usually NOT a dimensionless quantity. Only when radians are used is it dimensionless.

A ratio, such as 2.54 cm per inch, is not dimensionless, even though it expresses one length divided by another; the ratio has the "units" 'cm/inch.' Similarly, angle in degrees may be thought of as arc/radius, where r is in (say) feet—and we have no standard *Name* for the unit in which the arc is measured, but it is a unit equal to $\pi/180$ feet.

# A GENERAL BIOLOGY CLASS PREVIEWS ITS TEXT

CHARLES E. PACKARD
*Randolph-Macon College, Ashland, Virginia*

Do you, as a teacher surrounded today by a wealth of very helpful teaching aids, still believe in the basic usefulness of the text as a tool? Or do you recommend one merely from force of habit and because it is included in the system? Doubtless you recall that exceptional course in which an expensive volume was purchased to which no direct reference was made by the professor throughout his teaching? A transfer secondary school pupil was unable to give the name of the text which had been adopted because the teacher did not make use of it but preferred to originate his own lesson plans. What did your instructor mean when he casually remarked that he "didn't follow the text"? Was he minimizing its value? Probably he expected you to learn how to use it by yourself. And from the unused appearance of some copies that lie around in the classroom, cloakroom or library it would seem that the expectation remained but a hallowed dream.

The proper use of a tool is conditioned upon some knowledge of it. In order to disabuse the student of the idea that a textbook is decorative only a number of means may be used to ensure making its acquaintance other than by assignments. Some of these have been designed to show whether previous use of a more elementary one was developed to fullest degree, what critical abilities are now possessed, what background may have been built up for future analysis, whether there is a core of appreciation for the experimental method, how the book may appeal at first sight and impress so as to favor constant reference with study.

Interesting results at the college level have followed. A freshman girl from a class of forty-six in General Biology wrote in response to a request for a criticism of the text issued the first week of formal exercises: "To express a critical opinion on a textbook has been a new and puzzling experience for me. I have never before been challenged to analyze a book and thus recognize its superiority or inferiority in relation to others in the same branch of study. Yet in attempting to critically analyze my biology textbook I have gained a better understanding of its make-up and a greater appreciation of its finer points."

A sophomore girl began thus: "A person, devoting most of his time to a continuous practice of studying various subjects, forms a habit of glancing through his new text either with a critical attitude or a quizzical one. In doing so, he involuntarily reads the preface and introduction at the beginning of the text. Therefore, in writing this analysis . . . I can merely mention what I think is good and useful material written by the author, and what faults there are about the

book that, in my opinion, could be corrected." Her consequent performance was very commendable.

An upperclassman had four pages, concluding: "Taking into account all these points—which I believe seem to be favorable—there is no doubt that this book is a very admirable and commendable work of literature, from the standpoint of organization, material, illustrations, presentation, scientific approach, and the clarity with which it is written. From cover to cover it is interesting, enlightening, educational in the first degree, and superbly put together. (The authors) . . . have certainly accomplished their purpose when they set out to write this book—to bring to the budding biologist a good, clear, comprehensive and fundamental picture of the field of Biology." Lavish praise but he felt he had justified it.

The three criticisms are representative, by no means the finest nor the least acceptable of those submitted. One boy, whose entire offering consisted of the following, did not seem to know very much about how to proceed, an indication of his freshman status and lack of training: "In my sight the book seemed to be organized very well. It starts with a foundation and works up to more complex phases of biology. In its 870 pages it gives a most complete coverage of first course Biology. The size of the print is not too small, but the paper is too glossy for night reading. Excluding that one last point the book seems to be very good." Incidentally the person just quoted could not understand why he never secured A's on his papers nor did it satisfy him to be told that they were rated on a comparative basis of quality and coverage.

Analysis of the contributions resolves the subject matter into forty-two points treated. These overlap to a degree here and there but as expressed by the writer warrant separate listing. Various shades of meaning were conveyed in the thinking but the flavor of complete authenticity has to be sacrificed since it is obviously impossible to print each paper in full. A tabulation, therefore, centers around the subjects mentioned or implied.

| Subject | Criticism Favorable | Unfavorable | Mention Only |
|---|---|---|---|
| Acknowledgements | 3 | | 1 |
| Appearance | 4 | | |
| Appendix | 10 | 1 | 2 |
| Appraisal, General | 33 | 1 | |
| Appreciation | 1 | | |
| Approach, Scientific | 1 | | |
| Arrangement | 10 | 1 | |
| Authority | 10 | | |
| Bias | 1 | 1 | |
| Bibliography | 18 | 2 | |
| Binding | 2 | 1 | |

| Subject | Criticism Favorable | Unfavorable | Mention Only |
|---|---|---|---|
| Chapter Summary | 2 | 1 | |
| Completeness | 19 | 1 | |
| Content | 6 | 1 | 2 |
| Contents, Table of | 12 | | 7 |
| Definitions | 4 | | 2 |
| Enjoyment | 6 | | |
| Flexibility (Adaptability) | 11 | | |
| Footnotes | 2 | 1 | |
| Glossary | 33 | 1 | 1 |
| History of Subject | 5 | 1 | 2 |
| Illustrations | 41 | 1 | 1 |
| Impressions, Number of | 1 | | |
| Index | 23 | | 1 |
| Interest | 15 | 3 | |
| Introduction | 14 | | 4 |
| Italicization | 8 | | 1 |
| Language | 3 | | |
| Logic | 14 | 1 | |
| Organization | 27 | | 1 |
| Paper Quality | 5 | 4 | |
| Preface | 6 | | 6 |
| Presentation | 8 | 2 | 1 |
| Print, Easy Reading | 18 | 4 | 1 |
| Questions | 10 | 2 | 1 |
| Quotations | 4 | 1 | 2 |
| Repetition | | 1 | |
| Style | 3 | 1 | |
| Type Quality | 9 | | 1 |
| Understanding (Clarity, Comprehension) | 24 | 1 | |
| Up-to-Dateness | 3 | | |
| Vocabulary | 3 | | |

This is an impressive and varied array of opinion. Nineteen members expressed doubt as to their competency for qualified judgments due to such factors as unfamiliarity with the text, others for comparison, never having done such a task before, lack of knowledge of the field. Due allowance is to be made for the fact that the text had been in the hands of most students about a week. Even so one man had read four chapters. Quoting him, "I do not know whether it is the fact that I'm lazy but I rather enjoy the way this book has been written." Pertinent to the idea of more adequate judgment being had upon completion are these: "I will probably be a better judge of whether the book covers the necessary data or not at the end of the year rather than now."

"After seeing what I have of this book I am looking forward to reading it. I hope I will like it as much as I think I will."

"Regardless of the fine qualities which the book appears to possess, it will only achieve its goal if it has an accurate and well-written text."

"I have no deep rooted love for science, or any undying curiosity about my environment now and how it got to be the way it is. However, instead of the intense feeling of dislike that I felt towards biology (and sciences) previously,[1] has given way to one of hopeful interest. This book has excited my curiosity, and I think now that this course will prove profitable for me. At any rate the textbook yields such promise."

"With such an outstanding textbook my hope now is that I can retain its material, for if I don't I know the fault will lie with me, not with (it)."

"A repeated analysis of this book at the end of this course would without doubt be more complete but I think my general opinion would not be altered."

"I realize that biology is no easy subject, but one that is connected with every part of our daily lives. It will require much time and study on my part but with the aid of the textbook, and the services offered by the University I ought to be able to obtain the fundamentals of this particular science, and proceed to become a good student of biology."

"I believe that I will be satisfied with it[2] even if I were not, what good would it do me." (!)

A glance at the data will show that illustrations attracted most attention, the glossary and a general evaluation being practically tied for second place. Here are, then, two objective and one subjective feature leading all others, although a second abstract quality, organization, with a score of twenty-eight is not far behind. Understanding and index tie with twenty-five each, to balance the concrete with what is less obvious. Bibliography, completeness, and easy-to-read print are mentioned at least twenty times, leaving a slight edge in favor of objectivity.

Some curious divergences in thinking occur. The acknowledgments were cited because it led to confidence that outside sources had been consulted on the one hand. On the other it was thought that too many persons belonging to the same institution as the authors had been quoted, which would tend toward bias and prejudice. Notice, too, that four found the print difficult on the eyes, whereas eighteen did not; that five felt the paper to be of good quality with four differing. Three felt the text failed to arouse interest but fifteen said otherwise.

The quotations aroused the ire of one young lady who expressed herself caustically thus: "That scientists should be very sentimental

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[1] Quotations generally given as written. Parenthesis indicates author's correction or revision with one exception noted hereafter.

[2] Sentence should end and a second begin here.

in the choice of quotations at the beginning of chapters seems to me to be incongruous, etc., etc." A junior girl thought them "appropriate" while a freshman surpassed her associates with this comment: "A feature I found unique . . . and also very attractive is the short verse at the beginning of each chapter, by well known poets. For I believe all to(o) often we are inclined to study science abstractly, as a mere set of facts. These poems I believe will help to connect science with our every day (life)[3] world, and impress on us, that it is vital, living, and has a beauty that even poets can write about."

One youth felt that the historical chapter would be more appropriate at the beginning, whereas another said that it would be better to have it at the end because it would then be known what the pioneers in the field were up against and one would be in a better position to understand what they had done.

There was conflict in regard to style. A sophomore girl commends it by saying, "The facts are put down without fuss or bother for the observation of the reader, and not as an excuse for show (ing) abilities in writing the English language. This may seem a strange point to observe, but contrast with some of the other of my textbooks makes it obvious." A freshman disputed her classmate with: "The content is very well develop(p)ed but I think that it is too profuse and could be presented in a more simple(r) way. I should also like to see the outline of the lessons more clearly defined and some of the paragraphs shorter and more concise." A little different is this girl's idea that ". . . in a few parts the reading matter seemed more like a list of facts, rather than something written in a paragraph." A male senior believed that the reader's intelligence is not insulted by writing directed at a grade school child; a freshman boy commented, "The text starts in such a way as not even to frighten the most leery student." Another's praise was: "All in all I'd say this is a very fine book, not at all like the bor(e)ing and stuffy books I expected when I entered college. Formal, yes, but it is a science and science is facts which, I believe, necessitates formality."

It would hardly be expected that the abundance of illustrations would be objectionable yet a freshman woman found it so, thinking that there should be more descriptive matter. Yet another found certain sections overloaded with details. A freshman boy was overwhelmed by the problems, saying that "It would take a pretty good beginning biology student to answer all the questions at the end of the chapters." A more mature fellow pointed out that ". . . no science can be learned without the use of questions; the whole experimental basis of science is the question." He came to college with a background of investigation on enzymes and their action. It was he

[3] Student inclusion.

who noted the recent publication of the book and commented that it was "the first important thing when thinking" of science. Gratifying also was the statement of another that "there is enjoyment in finding and learning new facts. . . ."

From time to time an author is encountered who discounts the inclusion of a glossary in his production. Apparently this was one of the features most widely recognized as commendable by these students. They made interesting comments as to its probable value to them. A girl also brought out that it should be of aid to language students and noted that many of the scientific terms derived from Latin. Later the class was frequently reminded of the relationship to Greek.

The exercise proved very stimulating to all concerned. It was good to hear from an upperclass-G.I. the following: "It has been my experience, with many of our textbooks, to just struggle through in order to find or even figure out just what the important work seems to be implied in each chapter. I believe that the method . . . used to project the prime topics is very worthwhile and should prove valuable to freshman students who are just entering college and who, for the most part, have not as yet developed good study habits and good outlining methods." Why beneficial to read the foregoing? Because it confirms a feeling of the author's that his compulsory note-taking and submitting, in both secondary and college training, was not required in vain. The student learns by practice. How else does he gain perfection? Therefore, freshmen are obliged in the author's classes to take down and hand in a set of notes covering the lectures and discussions. They are encouraged in all ways possible to write, write, and write.

It was pleasing to find another teacher in agreement for one boy somehow gained the information from a "nextdoor neighbor," who spoke from experience, that "Anything by . . . should be good." This fellow considered the point to be "an interesting sidelight" on his assignment. It was one girl's belief that the project introduced her to the basic text "more thoroughly" than would otherwise have been the case, her conclusion being "Lesson learned: Always look over a text well before proceeding."

There is philosophic wisdom even among freshmen as evidenced by, "I don't believe there will ever be published a completely satisfactory textbook." We should end on a more hopeful note, however, and can do so appropriately with the determination expressed by one who felt sure after his analysis that he would benefit tremendously from the effort he intended to put into his work. A very great deal of industry and application did follow in due course, the class proving to be a very fine one in a great many respects.

# CALENDAR PROGRESS

VINCENT C. O'LEARY
*Jefferson High School, Lafayette, Indiana*

Of all the progress that man has made, it is ironical that here in the middle of the twentieth century we are using an irregular, unbalanced and unsettled calendar that was devised 2,000 years ago.

Until 21 September 1949, there was hope that we might start the year 1951 with an efficient, streamlined perpetual World Calendar. On that day, the fourteen-nation General Committee of the General Assembly of the United Nations postponed action on The World Calendar by a tie vote of four to four. Four abstained and two were absent. A simple majority was needed to obtain action at the Fourth Session.

The tie vote showed the United States, United Kingdom, Philippines and Denmark opposed to discussion of the Calendar reforms. Voting for discussion were Canada, China, Chile, and Venezuela. Abstaining were the U.S.S.R., Poland, Pakistan, and Brazil. Greece and France were absent.

This result has forced a new adoption date for The World Calendar, i.e., Sunday 1 January 1956, the next available date when both the Gregorian Calendar and World Calendar coincide.

The calendar we use today is essentially the one introduced by Julius Caesar in 45 B.C. Caesar's calendar had a regular arrangement of months—31 and 30-day months followed each other in regular sequence except that February had 30 days in leap years only.

A cringing Senate, wishing to flatter Augustus Caesar by naming an odd numbered month after him, broke Julius Caesar's regular month arrangement, added a day to August and mussed up the other months—February already deficient was cut to 28.

When Caesar undertook to reform the calendar he borrowed an astronomer and mathematician from Cleopatra—Sosigenes of Alexandria. Under the arrangement made effective by Caesar with Sosigenes' advice, leap year was to come in every fourth year. When Caesar was stabbed in the Senate, his calendar which was left to the Pontiffs to administer was first put out of kilter because the Pontiffs put in a leap year every third year. Augustus had to straighten this out 37 years later by cutting out 3 leap years.

The year is not quite $365\frac{1}{4}$ or 365.25 days long—the year is really only 365.242216 days in average length. This difference amounts to 11 minutes and 14 seconds per annum, and by the sixteenth century this error had accumulated to the extent that the spring equinox occurred on March 11 instead of March 21.

## FIRST QUARTER

### JANUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | | | | |

### FEBRUARY

| S | M | T | W | T | F | S |
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| 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | | |

### MARCH

| S | M | T | W | T | F | S |
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| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |

## SECOND QUARTER

### APRIL

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
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| 29 | 30 | 31 | | | | |

### MAY

| S | M | T | W | T | F | S |
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| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | | |

### JUNE

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| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| | | | | | * | * W |

## THIRD QUARTER

### JULY

| S | M | T | W | T | F | S |
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| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
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| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | | | | |

### AUGUST

| S | M | T | W | T | F | S |
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| 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | | |

### SEPTEMBER

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| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |

## FOURTH QUARTER

### OCTOBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | | | | |

### NOVEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | | |

### DECEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| | | | | | * | W |

*The Year-End World Holiday, W December . (365th day), Worldsday follows 30 December every year.

**The Leap-Year World Holiday, W June (an extra day), follows 30 June in leap years.

To correct this error, Pope Gregory XIII in 1582 decreed that October 5 should be October 15. Since Caesar's calendar made too many leap years—every four without exception—Gregory also decreed that century years should not be leap years unless their date numbers were exactly divisible by 400. Even this plan will give a slight error which will amount to one day in about 4,000 years.

The amended Julian Calendar, known as the Gregorian Calendar, is now used in practically all civilized countries; but its adoption was slow and painful. Gregory's revision had a strong religious flavor and coming as it did at the time when Protestantism was making headway it met with violent opposition. It took Germany 118 years after the Papal Bull had been issued to break away from the old order. Denmark and Holland also waited the same number of years before requiring by law the revised calendar. Although Scotland adopted the new style in 1600, England and the American Colonies clung to the Julian order for 170 years and Sweden a year longer. Even then, in England riots accompanied the carrying into effect of the new dates where the feeling of the laboring class was the loss of eleven days out of life with attendant loss of wages. Japan adopted the Gregorian Calendar in 1873, China in 1912 and Russia in 1918—336 years after the reform began. 300 millions of people in Asia, Africa, and eastern Europe have made the change since World War I.

The Gregorian Calendar with its unequal lengths of the months and many variations from year to year has not been a satisfactory tool for industry, finance, commerce, courts, schools or any other enterprise where it is necessary to determine dates in future years.

The proposed World Calendar has four equal quarters each consisting of thirteen weeks or ninety-one days and beginning on Sunday and ending on Saturday. Every month has twenty-six weekdays plus Sundays. The first month of each quarter has five Sundays, other months four Sundays. Holidays are fixed, falling on the same day every year, and thus the calendar has true comparability, not for a year but for centuries. The quarters of the year are equalized and the days of the week and dates always agree.

The World Calendar has only 364 numbered days. The 365th day known as W December or Worldsday comes between December 30 and January 1. Always coming between a Saturday and a Sunday it gives the world a three-day week end holiday which, it is hoped, will be celebrated in every country as an international holiday for world wide peace and unity.

Leap year day known as W June has been placed between June 30 and July 1. Falling between a Saturday and a Sunday it would supply another three-day weekend holiday, to be observed as such throughout the world.

There have been many unsuccessful attempts during the last 100 years to bring about a calendar revision. As early as 1834, an Italian priest, Marco Mastrofini, proposed a perpetual 12-month calendar of 364 days with the 365th day added as the closing day of the year and inserted between two weeks—giving a three day weekend.

In 1849, the French philosopher, Auguste Comte, proposed the Positivist Calendar. This plan called for a year of thirteen months of twenty-eight days each, the extra month called Sol coming between June and July.

Although this calendar was rejected by the Astronomical Society of France in 1887, it was revived in simpler form early in the present century by an English railway auditor named Moses Cotsworth, who advocated its adoption on the ground of simplification. After 20 years of effort, Cotsworth got the backing of George Eastman of Kodak fame. Eastman working with the United States Government got a National Committee established of which he was chairman; and a report issued from Washington in 1929 recorded an amazing amount of support for the 13-month calendar.

The disadvantage of this calendar is that much business is done on the quarter and half-year basis. Railways, banks, industries, utilities, governments, etc. issue reports and balance sheets quarterly and semiannually. For this purpose any 12-month calendar is preferable. Furthermore, as P. W. Wilson points out in his *Romance of the Calendar*, if the 13-month plan were adopted, "more than a quarter of the days of the year would have to be moved out of their months—a very grave disturbance of dates, civil, religious and personal."

To Elisabeth Achelis, President of The World Calendar Association, must go credit for putting before the nations a calendar more acceptable to the mass of people than one with 13 months. From a life of cultural and social diversions, Miss Achelis was aroused by antagonism to the 13-month plan proposals which she believed complicated rather than simplified the calendar. When, in 1930, she was confronted with a plan which appealed to her as a satisfactory solution of the problem, she cut loose from her former pursuits and pledged her considerable fortune and her talents to the cause. Untiringly, she demonstrated the superiority of the 12-month, equal quarter plan (The World Calendar) and soon became a leader in calendar reform.

In a relatively short period, most of the support for calendar reform obtained by the International Fixed Calendar League, on which Moses Cotsworth had been working for 25 years, was transferred to The World Calendar. A labor conference of the American countries endorsed The World Calendar at Santiago, Chile in 1936 and requested the League of Nations to study the question further.

In January 1937, the Chilean delegate submitted to the Council of the League of Nations an international draft convention for the adoption of The World Calendar. The Committee of Communications and Transit was then appointed to sound out the various States on the question in order to receive their replies before the following 1 August. Of the 45 governments which answered, only 14 declared themselves in favor of The World Calendar. However, only six nations positively rejected the project. On the basis of this survey, the Council at its 98th session, in September 1937, withdrew the question from its agenda.

Not long after this, World War II prevented further work being done on revision of the calendar through the League of Nations. The World Calendar Association, however, continued its campaign for calendar reform.

In 1946 a joint resolution was introduced in the Senate and House of Representatives calling for adoption of The World Calendar in the United States.

In 1947 and 1949 similar bills were introduced in the 80th and 81st Congresses respectively.

In 1949 The World Calendar was presented to the Fourth Regular Session of the General Assembly of the United Nations but no action was taken.

The World Calendar Association had planned to present their project to the United Nations General Assembly in 1950, but because of the Korean conflict it was not presented. If world conditions permit, it will be presented in 1951.

If United Nations approval can be obtained in 1951, the nations will have a full year, 1952, for ratification; and three preparatory years, 1953, 1954, and 1955, before the next available adoption date—Sunday, 1 January 1956.

If you are interested in promoting this much needed progressive change you should write to: The World Calendar Association, Inc., & Intl., International Building, 630 Fifth Avenue, New York 20, New York.

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## SWISS MOUNTAIN SCENE OF COSMIC RAY RESEARCH

The summit of Switzerland's 13,600-foot Jungfraujoch mountain will be occupied this winter as a cosmic ray observatory by four University of Manchester scientists who will study the production of meson atomic particles by these penetrating radiations from outer space.

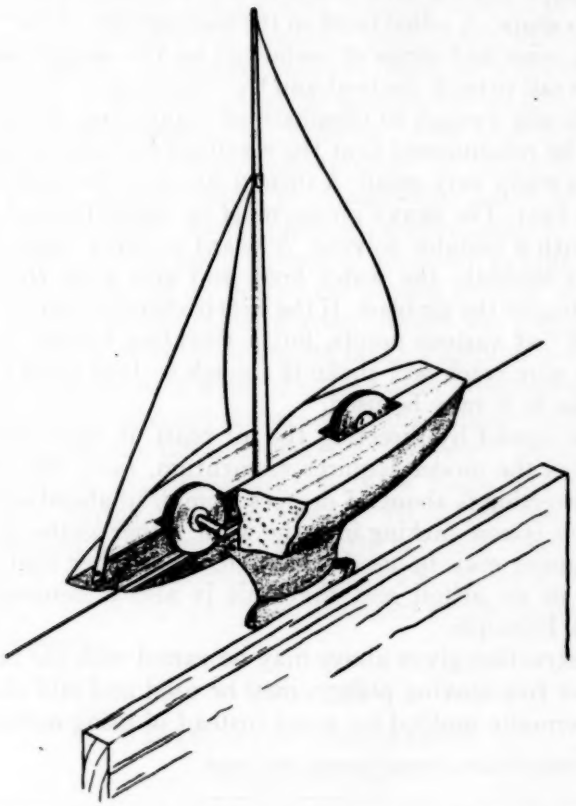
Dr. P. M. Blackett, Nobelist and British atomic scientist, will lead the team, which will use a 14-ton magnet and cloud chamber apparatus to observe the mesons, which are the particles that are involved in the constitution of the atomic heart.

Previous explorations of cosmic rays have led the same group of scientists to conduct experiments deep in London subways and British coal mines.

# A DEMONSTRATION SAILBOAT WHICH WILL SAIL AGAINST THE WIND

JOHN J. BOWEN
*Chicago City Junior College, Herzl Branch, Chicago, Ill.*

Inland students are usually not very convinced when shown the usual vector diagram of a boat sailing against the wind. They think of a boat keel as something to prevent capsizing rather than a device which provides an enormous lateral resistance and furnishes one of the vectors.



An ordinary model boat in a tub of water is not satisfactory because it drifts around easily and will move erratically rather than on a given course. The solution to this problem is to run the boat on a tightly stretched wire six to eight feet long. The wire provides absolute resistance to lateral motion and is analagous to a keel, and yet the boat may realistically "heel" over as it travels up the wire against the blast of an electric fan.

A wooden toy sailboat[1] about eight to ten inches long is sawed lengthwise as shown in the drawing, and spaces are cut out to hold two small ball-bearing aircraft pulleys. The pulleys are mounted on dowels which in turn hold the two halves together. A slot is cut in the wooden hull so that the wire passes through without binding.

The metal keel of the toy boat is retained and sufficiently weighted with solder wire to keep the center of gravity of the model below the suspension wire. The model will remain upright and "heel" away from the wind direction as it sails up the wire.

Ordinary cloth or plastic sails cannot be cut to a reasonable aerodynamic shape in such small sizes, hence thin sheet aluminum is cut and bent to shape. A rolled bead on the leading edge of the "mainsail" serves as a mast and strips of metal left on the smaller sail serve to anchor this sail to both the boat and the "mainsail." This type of construction is stiff enough to eliminate all supporting strings or wires.

It must be remembered that the resultant force available to move this boat is really very small. A turnbuckle must be used to keep the piano wire taut. The heavy grease must be washed out of the pulley bearings with a suitable solvent. A board or other obstruction may be used to simulate the water level and also keep the keel from causing a drag in the air blast. If the wire is slightly uneven, the model may "stick" at various points, but a vibrating buzzer hung at one end of the wire track will shake it enough so that even a wire with minor kinks in it may be used.

Start the model by directing the air blast at right angles to the track and as the model acquires momentum, move the fan so that the wind direction is about 45 degrees from dead ahead of the model. The sailboat is now tacking into the wind. Other angles of wind and sail adjustment may be used if desired. Remember that the sail is analagous to an airfoil and that this is also a demonstration of Bernoulli's Principle.

The construction given above may be varied with the materials at hand. Other free-moving pulleys may be used and stiff sheet plastic may be thermally molded for a sail instead of using metal.

[1] Drawing by George Goranson, Chicago Vocational High School.

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*Winter overshoes* are made of nylon except for crepe rubber soles. The outer fabric is a special nylon weave; the lining is a soft, deep pile nylon fabric. These boots are light in weight, well shaped, and offer a shield against both cold and wetness.

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The future of the world is left to highly educated races who alone can handle the scientific apparatus necessary for preeminence in peace or survival in war. I hope our education will become broader and more liberal.—WINSTON CHURCHILL.

# YOURS FOR THE DOING

## A UNIT IN GENERAL SCIENCE

MAITLAND P. SIMMONS
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Over a period of years of secondary science education, there has come a definite realization of the need for more improvement in organization and presentation of content. From long teaching experience with adolescents, the author has observed that these young people respond strongly to a genuine, personal interest in their doings. For a broader environmental response, pupil doings should be carried on actively in the classroom, always working toward a definite, practical goal. It is obvious that all subject matter does not lend itself readily to experimentation; however, there is an adequate number of simple and convincing experiments.* Of course it must be remembered that in any scheme to vitalize instruction in science, the teacher should be alert, always playing a leading part.

To illustrate an interesting avenue of approach in organization and presentation of content for ninth-year general science, the writer has selected the Topic Study: Respiration. Before the pupils commence the operational activity, they should make a suitable preparation by searching for answers to a set of well-chosen, informative questions. After a lively and spirited discussion of the subject comes the "Doing." The apparatus for this pleasant "Activity" should be previously placed on the demonstration table ready for pupil-teacher participation during the class period. To obtain effective results, students should be encouraged to neatly tabulate observations independently in their individual booklets. The planned experience is followed by a set of interpretative questions which should summarize the salient points.

### UNIT: AIR

### TOPIC STUDY: RESPIRATION

### INTRODUCTION

1. Why do trumpet players who have played strenuously throughout a great number of years eventually become unable to play?
2. What are three advantages of deep breathing? Why is good posture essential for this?
3. Explain the effect of tobacco on the respiratory system.
4. Why is the knowledge of the respiratory system helpful?

* Simmons, Maitland P. *The Young Scientist.* New York: Exposition Press, 1950. The book contains 35 ninth-grade general science classroom activities with functional and instructive illustrations.

5. Name some outdoor games that are particularly good for developing lung capacity.

6. What group of workers is likely to have a lung capacity below normal; above normal? Explain.

7. Why is a person more likely to become fatigued at the top of a high mountain than at sea level?

8. Name growths sometimes found in the noses and throats of children. What effect do they have on breathing?

9. What is the cause of "getting out of breath" when running fast? How do you account for getting a "second wind"?

ACTIVITY: TESTING AIR CAPACITY OF LUNGS.[1]

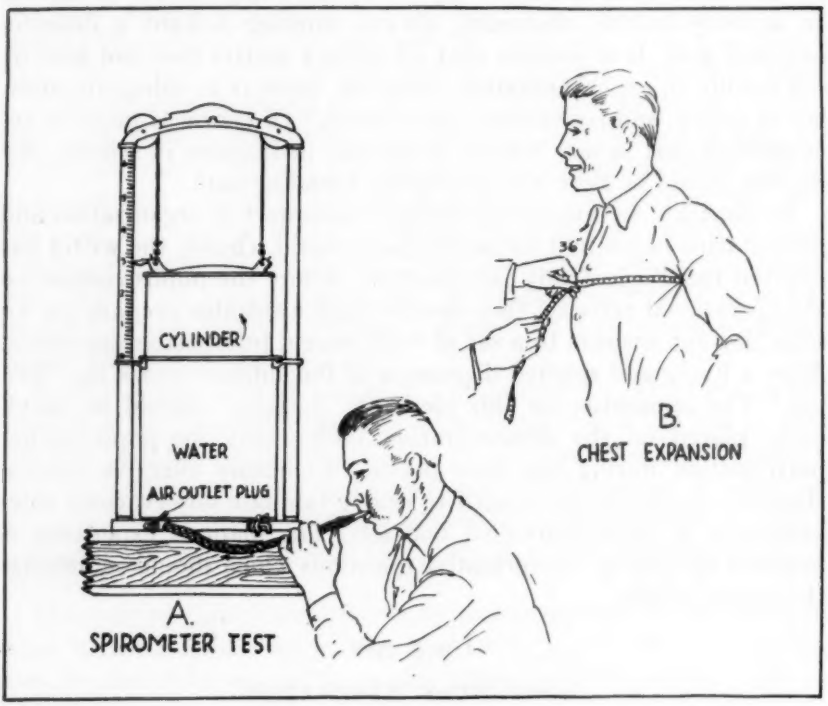


FIG. 1. Expansion of lungs.

10. Do you think that a person would die if his lungs were filled with carbon dioxide? Explain.

11. Why is artificial respiration necessary after a severe electric shock?

12. How is the breathing of animals and plants alike and unlike?

13. Discuss tidal and residual air. What is the amount of air we ordinarily inhale with each breath?

[1] To perform the full experiment, two class periods may be needed, depending on the size of the class.

Directions for Study:

A. Spirometer Test

Fill a spirometer[2] with water to within one inch of the top of the cylinder. Insert a rubber plug *tightly* into the air outlet. Take a deep breath before blowing vigorously into a sterile, wooden mouthpiece of the lung-testing apparatus. (*Caution:* Be careful not to "blow" too great a force as this extreme pressure may injure your inner-ear mechanism.)

At the end of each competitive test, remove the air-outlet plug. Press the inner cylinder *slowly* down to the base, and insert the plug *tightly* into the air outlet. Use a sterilized mouthpiece for each operation.

Tabulate the result. Compute the class average for boys and girls. (The exhaled air is recorded in cubic inches.)

B. Chest Expansion (boys)

With a tape measure, measure the circumference of the chest of each boy. Tabulate the measurement. Take a deep breath, measure along the line of the greatest expansion, and record the result.

Observation from Study:

A. Spirometer Test

Who showed the better performance, boy or girl? Why? What were their chest expansions? What was the class average? What is the normal capacity for boys, and for girls?

B. Chest Expansion (boys)

What was each boy's chest expansion? What was the class average?

## Interpretations

1. Houdini, the famous magician, in one of his acts was lowered in a sealed, air-tight coffin to the bottom of a tank of water for forty-five minutes. After the coffin was raised and opened, Houdini stepped out unharmed. Account for the fact that he did not smother.
2. Why might it be harmful to wear continually a tight belt around the waist?
3. Tell how insects, fish, and reptiles breath.
4. Why is "mouth-breathing" unhealthful?
5. How is air filtered and moistened on its way to the lungs of a human being? Why are cloth masks worn by workers in Duco-spraying or sandblasting industries?
6. Explain the use of an oxygen tent in the treatment of pneumonia. What are some other respiratory diseases?

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[2] This apparatus may be procured from the school's physical education department (gymnasium). If unavailable, secure a one-gallon glass jug such as used for distributing spring water. With labels for 1, 2, 3, and 4 quarts of water, mark a scale on the outside of the bottle for the level of each quart of water poured into it. When the jug is full, press a rubber stopper into it. Invert, mouth downward, in a collecting tray one-half full of water. Set the jug on a stand, remove stopper, and insert a rubber blow-tube under the mouth of the bottle.

7. Why can't a frog breathe if his mouth is open?

8. How is it possible for a whale, which is an air breathing animal, to remain under water for 45 minutes, as it sometimes does?

9. Why does a fish die if it is kept out of water for a sufficient length of time?

10. If a person in a mine is trapped by caving walls, should he remain as quiet as possible, or should he exert himself? Explain.

11. Before stratosphere balloonists begin their ascent from the earth, what procedure do they follow as an aid to their breathing?

12. Why are flowers and plants usually removed from a sickroom at night?

13. If the air contains about one-fifth oxygen, and oxygen is considered healthful, would air containing five times as much oxygen be five times as healthful? Why?

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## FILMS FOR MATHEMATICS TEACHERS

As a special service to mathematics teachers interested in expanding their use of classroom motion pictures, Coronet Films has just prepared a special new catalog of their 16 mm pictures on mathematics.

Films for all grade levels are included in the listing. Titles range from *Let's Count*, designed for primary grades, through such senior high subjects as *The Meaning of Pi*, *The Language of Mathematics*, and *The Language of Graphs*.

In addition to these basic mathematics films, many related titles, such as *Federal Taxation*, *Fred Meets a Bank* and *Banks and Credit* are included in the catalog.

All these Coronet instructional films were produced under the personal supervision of outstanding academic authorities who served as Educational Collaborators. Copies of the mathematics films catalog may be had free by writing: Dept. P, Coronet Films, Coronet Building, Chicago 1, Illinois.

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## STRAY DOGS NEEDED FOR RESEARCH

University of Wisconsin regents Saturday took action to eliminate the "unnecessary shortage" of dogs for teaching and research purposes in the University of Wisconsin Medical School.

The regents requested the state attorney general to "take appropriate action to obtain compliance" with the state law requiring that the humane societies turn over stray dogs to the Medical Schools at the University of Wisconsin and Marquette university.

In asking the regents to take action, Dr. H. M. Coon of the University hospital said that "the use of animals for teaching and research purposes by the medical schools of the country is an essential part of the education of doctors, and the provision of improved medical service for the citizens of the country."

Dr. Coon pointed out the "advances that have come through this type of research," citing the work done with dogs which has resulted in saving the lives of blue-babies and other "cardiac cripples" and in saving the lives of diabetics.

"These," he said, "are the two presently outstanding achievements which owe their adaptation for the sufferers from these conditions to the use of the research animals and especially dogs."

# THE PROBLEM OF MOLECULAR MODELS

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If one of your special interests is structural chemistry, you have probably discovered that the sets of molecular models now on the market are either very expensive, or they cannot be used to construct models to scale. Yet the emphasis placed on the spatial configuration of molecules and ions by many of the newer textbooks makes the scaled models a highly desirable teaching aid. Hence the question arises, can we chemistry teachers have models made under our own supervision? If we can, we shall have the models we need, permanently assembled and built to scale in the way we decide is the best for our own particular purposes. Let us consider some practical points in model construction.

## WHAT MATERIAL SHALL WE USE?

Wood is the material of which many of the sets of models now on the market are made, as well as the ones built privately for Dr. J. A. Campbell of Oberlin College. Photographs of his models accompany the articles he has recently published in the *Journal of Chemical Education*.[1,2,3] Wood working, however, demands tools, techniques, and hours that are not always available.

A crystal model set that has been on the market for a year or two uses colored rubber balls of uniform size and cellulose acetate connectors. Rubber balls can be obtained in a number of sizes, but it is practically impossible to use them to build exactly scaled models. Papier-mache and the plastics offer possibilities that have not been thoroughly investigated.

A very practical material for the making of molecular models on a small scale is clay, not molding clay, but the water clay used by classes in ceramics. This clay can be purchased dry or moist from any ceramist's shop in ten-pound lots for about six cents a pound. When we make models of clay, we borrow the Physics department's entire supply of vernier calipers, and take them along with our data, rulers, heavy wire, substantial pliers for wire cutting and bending, and protractors for the measurement of angles, to the pottery room and use their clay and equipment. If a pottery room and its equipment are not available, an earthenware crock or a can in which the clay can be kept moist, a pan of water, a few metal spatulas or knives, and a washable table can certainly be obtained.

[1] Campbell, J. A., "Atomic Size and the Periodic Table," *Journal of Chemical Education*, 23 (November, 1946), 525–529.

[2] ——— "Structural Molecular Models," *Journal of Chemical Education*, 25 (April, 1948), 200–203.

[3] ——— "Structural Chemistry," *Journal of Chemical Education*, 25 (October, 1948), 558–562.

One pair of vernier calipers should be set to the diameter of each of the atoms to be represented in the models under construction, and the moist clay rolled in the hands of the worker until perfect spheres of the desired size, as measured by the vernier calipers, are obtained. These balls are joined, while the clay is still moist, by pieces of heavy wire which reach approximately from center to center of the spheres. After these spheres have been pressed together to the degree that will be indicated later, the outer surface of the clay can be smoothed with water, and the models allowed to dry slowly by exposure to air. Firing of the models in a kiln is not necessary if they are to be painted when they are thoroughly dry.

### Which Is the Best Scale?

If the models are to be used in classes of thirty or fewer students, the best scale is probably one centimeter to an Angstrom unit. For larger groups, the scale of one inch to an Angstrom unit is preferable, since models of this size are large enough to be seen easily by students in a lecture hall. The use of either of these two scales makes possible the setting of the vernier calipers by simply referring to a list of diameters or radii of atoms, since these dimensions are almost always given in Angstrom units. The larger the clay spheres used in the construction of the models, the more difficult is it to make the spheres perfectly round, and the greater is the danger of their cracking. A scale of two or more inches to an Angstrom unit is, therefore, not advisable if water clay is used as the raw material.

### Who Will Make the Models?

To make good models, the worker must be accurate, painstaking, and must have a fairly high degree of manual dexterity. Some chemistry teachers may want to make clay molecular models themselves, but many of them will find among their assistants or students someone who is both able and willing to do the job, and who will learn a great deal while doing it. Once the data have been gathered and the knack of manipulating the clay has been acquired, models can be turned out without a great expenditure of time.

### What Models Shall We Build?

A chemistry teacher will want models of the molecules and ions most frequently mentioned in his classes. For high school or first year college chemistry, this would include molecules of water, hydrogen, oxygen, and nitrogen gas, the halogens and their hydrides, ammonia and the oxides of nitrogen, phosphorus, sulfur and its oxides, hydrogen sulfide, carbon tetrachloride, the simpler hydrocarbons, and possibly other organic compounds. The ions should include the hy-

dronium, ammonium, nitrate, and sulfate ions. Models of the atoms and corresponding ions of the alkali metals and the halogens are useful in showing the difference in size of the atom and the ion formed by the loss or the gain of a single electron. A sodium chloride crystal of tangent spheres can be easily made by joining with wire the moist clay models of fourteen chloride and thirteen sodium ions, in the well known arrangement of three planes of nine ions each, alternating the types of ions.

## How Can We Determine the Spatial Configuration of Molecules and Ions?

According to Dr. Ralph Wyckoff, "Atoms in crystals as in other forms of matter are not sharply bounded and it is accordingly highly debatable what physical meaning should be attached to radii other than as devices for expressing relative 'sizes' and additivity relationships."[4] For our purposes, this interpretation of atomic radii is sufficient, and we shall consider bond distances as being practically equal to the sum of the radii of the two bonded atoms. The effective radius of an atom, however, depends to a large extent on its oxidation number and on the multiplicity (single, double, or triple) of the bonds it forms with adjacent atoms. For a particular element, a triple-bond radius is always less than a double-bond radius, which in turn is less than a single-bond radius. Pauling gives the radii of these three types listed in Table 1.

Table 1. Covalent Radii for Atoms[5]

| | H | | | |
|---|---|---|---|---|
| | 0.30 Å | | | |
| | C | N | O | F |
| Single-bond radius | 0.771 | 0.70 | 0.66 | 0.64 Å |
| Double-bond radius | .665 | .60 | .55 | .54 |
| Triple-bond radius | .602 | .547 | .50 | |
| | Si | P | S | Cl |
| Single-bond radius | 1.17 | 1.10 | 1.04 | .99 |
| Double-bond radius | 1.07 | 1.00 | .94 | .89 |
| Triple-bond radius | 1.00 | .93 | .87 | |

Atomic radii, as given in the literature, are classified as ionic, covalent (bonded), and van der Waals (non-bonded). The covalent radii are always smaller than the corresponding van der Waals radii, because there are fewer levels of electrons between bonded than between non-bonded atoms. Ionic and van der Waals radii are about

[4] Wyckoff, Ralph W. G., *Crystal Structures*, 1948, chapter III, text p. 6.
[5] Pauling, Linus, *Nature of the Chemical Bond*, 1940, p. 164.

equal since "the bonded atom presents the same face to the outside world in directions away from its bond as the ion . . . does in all directions."[6] Changes in van der Waals radii are found to be smaller than the corresponding changes in covalent radii, but follow the same pattern.[7]

In the construction of clay models, ionic or van der Waals radii are to be preferred to the covalent for the making of the spheres, and

TABLE 2. ATOMIC AND IONIC RADII

| Atomic Number | Element | Van der Waals Radii[1] | Covalent Radii[2] | Atomic Radii[3] | Ion | Ionic Radii[4] |
|---|---|---|---|---|---|---|
| 1 | H | 1.2 A | 0.30 A | | $H^-$ | 1.27 Å |
| 2 | He | | | 0.8 Å | | |
| 3 | Li | | | 1.50 | $Li^+$ | 0.70 |
| 6 | C | | 0.77 | | $C^{4-}$ | 2.60 |
| 7 | N | 1.5 | 0.70 | | $N^{3-}$ | 1.48 |
| 8 | O | 1.40 | 0.66 | | $O^{2-}$ | 1.35 |
| 9 | F | 1.35 | 0.64 | | $F^-$ | 1.33 |
| 10 | Ne | | | 1.60 | | |
| 11 | Na | | | 1.86 | $Na^+$ | 1.00 |
| 14 | Si | | 1.17 | | | |
| 15 | P | 1.9 | 1.10 | | $P^{3-}$ | 1.86 |
| 16 | S | 1.85 | 1.04 | | $S^{2-}$ | 1.82 |
| 17 | Cl | 1.80 | 0.99 | | $Cl^-$ | 1.80 |
| 18 | A | | | 1.91 | | |
| 19 | K | | | 2.27 | $K^+$ | 1.33 |
| 35 | Br | 1.95 | 1.11 | | $Br^-$ | 1.96 |
| 36 | Kr | | | 2.0 | | |
| 37 | Rb | | | 2.43 | $Rb^+$ | 1.52 |
| 53 | I | 2.15 | 1.28 | | $I^-$ | 2.20 |
| 54 | Xe | | | 2.2 | | |
| 55 | Cs | | | 2.62 | $Cs^+$ | 1.70 |

[1] Pauling, Linus, *Nature of the Chemical Bond*, 1940, p. 189.

[2] Pauling and Huggins, *Zeits. Krist.*, 87 (1934), 205, as quoted in Rice, O. K., *Electronic Structure and Chemical Binding*, 1940, p. 319. The radius of H is from Pauling, Linus, *Nature of the Chemical Bond*, 1940, p. 164.

[3] Neuburger, M. C., *Zeits. Krist.*, 93 (1936), 1, as quoted in Stillwell, Charles W., *Crystal Chemistry*, 1938, pp. 417–418. The radius of He is from Pauling, Linus, *College Chemistry*, 1950, p. 232.

[4] Wyckoff, Ralph W. G., *Crystal Structures*, 1948, chapter III, table p. 15.

when the bond between two atoms is known to be covalent, the spheres can be pressed together until the distance between their centers is as close as possible to whatever the bond distance (approximately the sum of their covalent radii) would be on the scale used.

When the decision to build molecular models is made, therefore, the first data needed are the van der Waals or ionic radii of all the atoms concerned. Table 2 lists these radii for the most frequently used atoms, and their covalent radii if they form covalent bonds.

[6] *Ibid.*, p. 188.

[7] Campbell, J. A., "Structural Chemistry," *Journal of Chemical Education*, 25 (October, 1948), 559.

Table 3 gives bond angles and bond distances—the distances between atomic nuclei which are here considered as points. Additional data may be obtained from the journals or from such books as those referred to in the footnotes of this paper.

TABLE 3. BOND DISTANCES AND BOND ANGLES[1]

| Formula | Bond | Distance | Bond | Angle | Notes |
|---|---|---|---|---|---|
| $H_2O$ | O-H | 0.97 A | H-O-H | 105° | |
| $H_2$ | H-H | 0.74 | | | |
| $F_2$ | F-F | 1.46 | | | |
| $H_2S$ | | | H-S-H | 92° | |
| $NH_3$ | N-H | 1.01 | H-N-H | 108° | Tetrahedral molecule |
| $N_2O$ | | | N-N-O | 180° | Linear molecule<br>Oxygen atom at one end |
| NO | N-O | 1.14 | | | |
| $NO_2$ | N-O | 1.18 | O-N-O | 140° | These values are a prediction |
| $P_4$ | P-P | 2.20 | P-P-P | 60° | Tetrahedral molecule |
| $S_8$ | S-S | 2.08 | S-S-S | 106° | Staggered ring of eight atoms |
| $SO_2$ | S-O | 1.43 | O-S-O | 121° | |
| $CCl_4$ | C-Cl | 1.77 | Cl-C-Cl | 109° | |
| $CH_4$ | C-H | 1.093 | H-C-H | 109° | |
| $C_2H_6$ | C-H | 1.09 | H-C-H | 109° | |
| $C_2H_4$ | C-H | 1.087 | H-C-H | 109° | All atoms in one plane |
| $C_2H_2$ | C-H | 1.06 | H-C-C | 180° | Linear molecule |

[1] These data are from Pauling, Linus, *Nature of the Chemical Bond*, 1940, pp. 79, 80, 128, 165, 168, 247, 267, 270. The experimental error in a bond angle is usually about 3°.

The radius of hydrogen varies to a much greater degree than the radius of any other atom, but the usual procedure of using its van der Waals radius in the construction of the sphere and pressing it against the one to which it is bonded, can still be employed. After the pressing, the distance from the original center of the hydrogen sphere to its junction with the one to which it is bonded, should be approximately equal to the length which represents 0.30 Å (the average covalent radius of hydrogen) except in the case of $H_2$ where the covalent radius is 0.37 Å.[8] Sometimes a sketch of a molecule[9] or a picture of its model[10,11] makes the construction easier.

## HOW SHALL WE PAINT THE MODELS?

When water clay is thoroughly dry, it will take enamel and aluminum paint. Brightly painted models are much more attractive and

[8] Pauling, Linus, *Nature of the Chemical Bond*, 1940, p. 168.

[9] ———, *General Chemistry*, 1947, p. 129.

[10] Campbell, J. A. See footnotes 1, 2, 3.

[11] Sisler, Harry H., Vanderwerf, Calvin A., and Davidson, Arthur W., *General Chemistry, A Systematic Approach*, 1949, pp. 232, 400, 412, 462, 473, 491, 503, 521, 526, 528, 579, 608, 829 carry pictures of Dr. Campbell's models.

instructive than those of dull gray, so we decided to paint the models and to follow the color scheme which assigns a different color to each element involved. We use aluminum paint for the hydrogen atoms, because chemically, hydrogen is more metallic than non-metallic. Bright enamel is used for the non-metallic elements according to this scheme:

| *Color* | *Element* |
|---|---|
| Red | Oxygen |
| Blue | Nitrogen |
| Yellow | Fluorine and Sulfur |
| Green | Chlorine |
| Orange | Bromine |
| Violet | Iodine |
| White | Phosphorus |
| Black | Carbon |
| Aluminum | Hydrogen and Sodium |

The scheme would have to be changed if models of all possible atoms were to be painted. In that case, color could be used to denote the family and shade or hue the particular element. Dr. J. A. Campbell uses this latter method and lightens the shade as he goes down the periodic chart. Fluorine models, for example, are painted dark green and iodine light green, with chlorine and bromine in between. Some teachers might want to follow the colors of the spectrum in assigning colors to the families of the periodic chart, giving red to the alkali metals, orange to the metals of group two, etc.

## Shall We Label Them?

Once students are familiar with the particular color scheme followed in painting the models, labels are not necessary, hence there is no reason for attaching tags to the models. To keep them in order, however, it is well to have a shallow box or tray of some sort subdivided into cubicles. The bottom of each cubicle could be labelled with the formula of a molecule or ion, and the corresponding model kept in that cubicle when it is not in use. Printed labels are an asset when the models are put on display.

## Advantages of Structural Molecular Models

Once a set of permanently assembled scaled models is built and painted, it can be used to interpret many of the chemical and physical properties of substances, as well as differences in behavior among the members of a sequence such as the halogen hydrides. These models are invaluable throughout the year in focusing the attention and the senses of the students upon the subject under discussion, and no one will deny that Aristotle was right in saying that there is nothing in the intellect that was not first somehow in the senses.

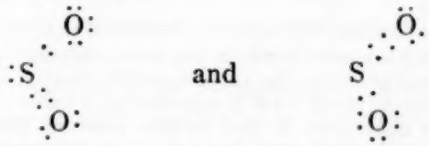
The models are also of value in showing relationships, and what greater need is there in science courses today? The relationships range from simple ones, such as that between a molecule and its formula, up to and beyond the effect of unbounded electrons upon the bond angle in a triatomic molecule. Consider $N_2O$ and $SO_2$ for example. Since nitrogen has five valence electrons and oxygen six, $N_2O$ has a total of 16 valence electrons. The nitrous oxide molecule is linear with the oxygen atom at one end. The most stable electron structures are

A: :N::N::O:

B: :N:::N:O:

and we "expect the normal state of the molecule to correspond to *resonance between structures A and B*, with perhaps also very small contributions by the other less stable structures, which can be neglected in our discussion."[12] The models of A and B would not differ, except for a slight change in bond distances, which could be neglected.

Sulfur, like oxygen, has six valence electrons, so that the $SO_2$ molecule has a total of 18 valence electrons, and we would expect resonance between the structures:




and the value of the O-S-O angle is 121°.[13] Again the two resonating forms would have the same model, but notice that $SO_2$ is a bent molecule and has an unbounded pair of electrons on the central atom, while $N_2O$ is linear with no unbonded valence electrons on the central atom. Further investigation leads to the conclusion that $N_2O$ is a typical linear triatomic molecule, while $SO_2$ is a typical bent one, and that in a triatomic molecule a bond angle considerably less than 180° is evidence of one or more unbonded electrons on the central atom.

Not the least of the advantages of a set of structural molecular models is that the models lead their possessor to a study of such relationships as the one stated above, and of such interesting phenomena as resonance in molecules.

[12] Pauling, Linus, *Nature of the Chemical Bond*, 1940, p. 126.
[13] *Ibid.*, p. 247.

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*Tiny hearing aid* is nearly unnoticeable in the user's ear, being only slightly larger than the button on a man's shirt. It has very wide frequency range, and also high and low tone control to provide sound selectivity at either end of the range.

# TRANSFORMATION OF COORDINATES: A SEQUEL

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Undoubtedly the opinion of authors Read and Wrestler (SCHOOL SCIENCE AND MATHEMATICS, Volume L, page 559) that the use of the transformation equations relating rectangular and polar coordinates requires caution beyond that prescribed by most texts will find many adherents. While I am among this group, on the basis of the example cited I am not convinced that ". . . the customary transformation equations do not always yield equivalent loci."

Consider again $r=\sec^3\theta$ and perform the transformation in detail as follows:

$$\frac{1}{r}=\cos^3\theta \qquad \text{(not satisfied by pole)} \qquad (1)$$

$$\frac{1}{r}=\frac{x^3}{r^3} \qquad \text{(not satisfied by pole)} \qquad (2)$$

$$r^3=x^3 \qquad \text{(satisfied by pole)} \qquad (3)$$

$$x^3+y^3=x^3 \qquad \text{(satisfied by pole)} \qquad (4)$$

Note that the use of the transformation equation $x=r\cos\theta$ does not affect the equivalence of (1) and (2) as far as the pole is concerned; nor is the equivalence of (3) and (4) disturbed by the use of $x^2+y^2=r^2$. The introduction of the pole as a point satisfying the locus evidently occurs in multiplying both members of (2) by $r^3$ to obtain (3), yet this operation involves none of the transformation equations in question! Is it not true, then, that the source of the difficulty is rather of an algebraic nature?

It would seem the student had better be reminded that the principle (presumably encountered in his earlier work in algebra) whereby both members of an equation may be multiplied by the same quantity tacitly, if not explicitly, excludes zero. With this in mind, $r=0$ is excluded as a value satisfying (3) or (4), and (1) and (4) are equivalent in that neither contains the pole. Having thus handled the algebra with the rigor it demands, here at least there seems to be no cause for associating any erratic behavior with the transformation equations insofar as their preservation of loci is concerned.

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# TRANSFORMATION OF COORDINATES—COMMENTS

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*University of Wichita*

The remarks by Mr. Townsend are very well stated, and he is indeed correct that the fundamental difficulty may be one of proper algebraic operations, rather than any error in the transformation equation used.

The statement that $r=0$ is excluded as a value satisfying (3) or (4) is debatable. Equation (4) does not involve $r$. A generally accepted test to determine whether or not a point is a part of a locus is to substitute the coordinates of the point—this test does not require that one investigate how the equation was derived. Using this test, the pole, having rectangular coordinates (0, 0), is a part of the locus defined by equation (4).

To the student, however, the pertinent question remains unanswered: How does one obtain the rectangular equation of the locus which contains all the points, and only such points, as are defined by the given polar equation?

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Well done is better than well said.—FRANKLIN

# THE OSCILLOSCOPE IN HIGH SCHOOL PHYSICS DEMONSTRATIONS

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If we are to judge by the number of articles on the cathode-ray oscilloscope that have appeared in educational journals and are recorded in *Education Index* this must be a very neglected piece of demonstration equipment in high school physics courses. It would be a pity indeed, if the total of sixteen such articles over a period of twenty years should constitute a criterion of use and appreciation of the oscilloscope. No doubt many a physics teacher prizes the C.R.O. for its versatility. It is with this in mind, as also to introduce the C.R.O. where it is as yet unknown, that this enumeration of demonstration is offered.

There are but two classes of phenomena that can be made easily visible with the aid of the oscilloscope: a. electrical transients; b. sounds. Mechanical motions which may be translated into electrical pulses will be omitted in this article. The use of the oscilloscope in radio and television servicing are here also deliberately omitted, as these uses are amply covered in service manuals. In the first class the electrical pulses, provided they are within the range of 3 to 400 volts, r.m.s. are fed directly into the oscilloscope. These are the practical operating voltages of most oscilloscopes. In the second class, sounds must be picked up first by a microphone and the electrical impulses generated must be amplified to a proper voltage to actuate the oscilloscope.

## REVIEW OF THE LITERATURE

The coming of age of the oscilloscope coincides roughly with the date that it emerged from the status of a test instrument in the research laboratory and found its place as a control in the manufacturing world. This date can be fixed approximately by the issuance of trade literature on the specifications and uses of the cathode-ray tubes. In 1935 the R.C.A. Mfg. Co. published its *Cathode-Ray Tubes and Allied Types. The Oscillographer*, a house organ by Dumont, made its initial appearance two years later. Since then there seems to have been a definite sequence in the articles appearing in journals: (a) articles on specifications; (b) articles of a theoretical nature and articles on experimental practices; (c) and lastly, articles on the use of the C.R.O. in industrial control.

From 1935–1937 forward the volume of literature and references in journals has steadily increased, though at present the output seems

to be leveling off. While the total output of related literature is rather large, the number of pertinent articles is exceedingly small.

The *Education Index*, as previously mentioned, was found to be the best source of pertinent materials. In *The American Physics Teacher*, under its newer name *The American Journal of Physics*, was found the only useful reference, and even in this journal only four out of ten references are helpful at the high school level.

Although the *Cumulative Book Index* lists twenty-eight books of both American and English publication, only ten of these are available. Very few of the available books contribute anything to the demonstrations.

*Readers' Guide to Periodical Literature* with its voluminous references is of little or no help. Most of these references are to popular magazines, which are almost exclusively devoted to radio and television repair and servicing. If we take the number of references appearing as a measure of the use of the cathode-ray oscilloscope, then there has been a great increase in its use since 1943.

*Science Abstracts* reports only on the uses of the cathode-ray tubes as an industrial control.

Considering how few are the gleanings from the literature as also its scattered location, it is the purpose of this article to bring together the thoughts and experiences of many teachers. The demonstrations here listed should fill a gap in high school physics demonstrations. But this enumeration is not to be regarded as minimal nor exclusive of further additions.

## PART 1. ELECTRICAL TRANSIENTS

### Alternating Current

*Sine Wave.* Among the primary concepts which must be stressed with students at the very beginning of the study of alternating currents is the fluctuation of voltage and of current pulses through 360 electrical degrees. Inseparably linked to the concept of alternations is the concept of wave form. Because the oscilloscope by means of its amplifiers can easily distort impressed electrical transients and thus display a falsified image, great care should be taken at this first demonstration that the trace on the cathode-ray screen be a pure sine wave in its true proportions. Most oscilloscopes contain a *test signal* supply. This binding post when connected to the *vertical input* may give a trace which is 180 degrees out of phase. To right the trace, connect the *test signal* also to the *synchronizing selector* with the *selector* switched to *external.*

After the trace of the pure sine wave has been explained—physics classes usually contain trigonometry students, and to them also it is of great importance to see a correct image—the trace might be al-

lowed to travel slowly from left to right. This is accomplished by a slight change in the synchronization. Physics students at various times have expressed to the author their preference for the distorted or amplified trace rather than the true sine wave.

*Other Forms.* Lest students get the false impression that the pure sine wave form is always the form obtained from alternators, it might be well to demonstrate forms which differ radically from those in commercial supply lines. The ubiquitous St. Louis Motor, or its equivalent the Genemotor, when used as an alternating-current generator delivers a square wave form rather unusual in appearance. Another quite different wave form is obtained from the hand-driven, bell-ringing magneto of the country-line telephone. These magnetos can be connected at the same time to a neon lamp (NE-34) containing semicircular disk type electrodes. The lamp gives one kind of demonstration of alternating current, while the trace on the screen shows a rather highly peaked wave.

Where the teacher would feel justified to include saw-toothed waves among his demonstrations, a discharge pulse through a gas filled tube such as a 2 w. neon bulb (NE-34) can be shown. In parallel with this tube is a 0.1 or 0.5 mfd. condenser. This wave generator in turn is in series with a 2–5 megohm rheostat. A direct current of 100 v or more energizes the circuit. The assembly gives pulses of one per second or more depending on the voltage, and on the resistance and condenser sizes. The oscilloscope is connected across the wave generator.

If the full-wave rectifier with its filter circuit is available, saw-toothed waves can be obtained from it by using condensers only in the filter circuit. The same wave form can also be obtained from the voltage-doubler circuit.

## Direct Current Pulses

The beautiful illustrations used in textbooks and diagrammed so accurately for direct current pulses are difficult to obtain on the cathode-ray screen. Fluctuations in the voltage of generators running at 1700 r.p.m. are very small, and require full amplification to become visible. With a four-brush take off in a motor-generator and with the *vertical input* amplifier full on, there is hardly a ripple visible. Masking the ripple and adding to the difficulty of demonstration are those transients introduced by the sparking of the brushes. Loading the generator to half capacity output and placing a very large condenser across the load, a much more distinct image is obtained. Using the experimental laboratory type St. Louis Motor or the Genemotor, and running these as direct-current generators and at considerably lower speed, a more pronounced ripple is obtained with an astounding wave

form. The automobile generator driven by belting to an A.C. motor can be another source of direct-current pulse demonstrations.

## Rectification

*Full Wave.* The phenomenon of rectification of alternating current becomes of interest to students when they realize that the type of current supplied to homes and to manufacturers is alternating and as

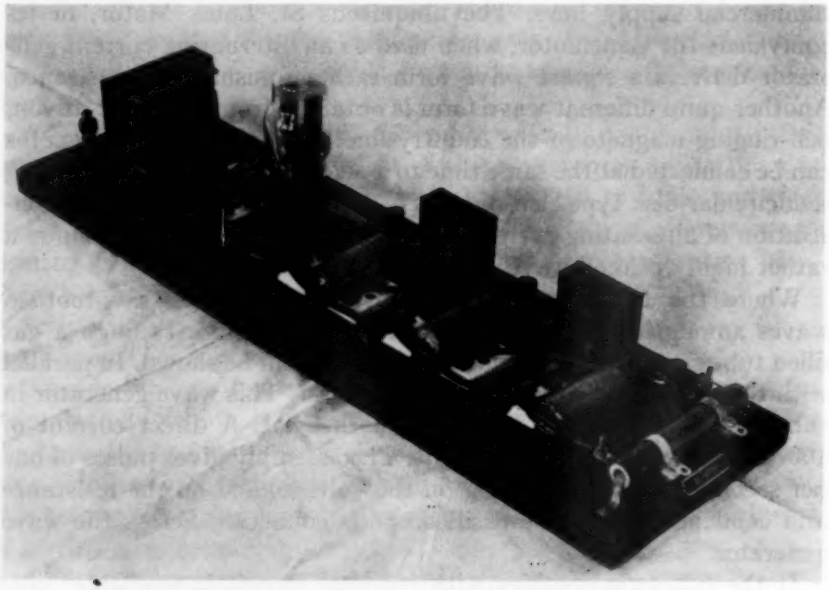

Fig. 1. Vacuum Tube Full-wave Rectifier with Filter System.

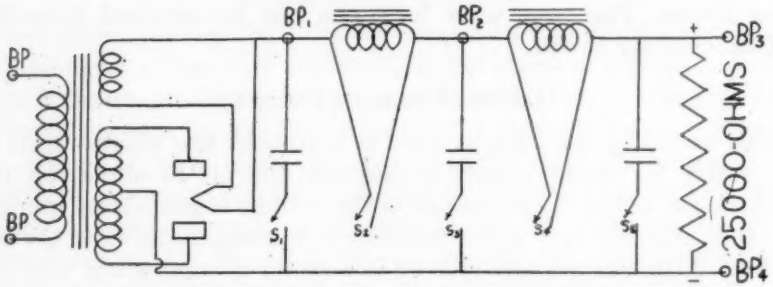


Fig. 2. Circuit for Full-wave Rectifier with Filter System.

such wholly unsuitable for some uses of electricity. Possibly the easiest and most evident demonstration of a rectifier is to be found in a very old form, the electrolytic rectifier.[1] For step one, demonstrate the input to be alternating in character; for step two, demonstrate the output to be a full-wave rectified current. A small load on

[1] Corby, A. F., Jr., Monograph B-7, pp. 82–94. Weston Electrical Instrument Corporation, Newark, N. J.

the output side is necessary for good wave form. The wave form and the polarity are also of interest. If the cuprous-oxide type, full wave bridge is available, needle point prods may come in handy to the take off on the supply chord. At times the rectification of these cuprous-oxide rectifiers as well as the selenium bridges is not perfect. If the proper range of voltmeters is used in conjunction with the oscilloscope, added comprehension can be achieved.

*Half Wave.* The phenomenon of half-wave rectification, the quenching of one-half cycle, is something that usually holds great interest to beginning students. A diagram before a demonstration is imperative. The older type of Tungar rectifier fed into a rheostat gives a very good picture. If the amplifier is turned up, a beautiful set of ripples in the half-wave frequently becomes visible. If a Tungar is unavailable, a type '81 tube rectifier with its transformer will substitute. A potentiometer across the output will be needed in this case because the oscilloscopes have input voltage limits. Full-wave rectification tubes can also be connected to operate as half-wave rectifiers. A single cell of the electrolytic type half-wave rectifier is the least expensive and produces an atypical wave form with resistance ballast only.

*Filter Systems.* The everyday use of filter circuits in the power supply of alternating-current operated radios is both a recommendation and a justification for the demonstration of this phenomenon to high-school classes. Depending on the completeness of the demonstration desired, or the degree of instruction in the practical and useful to be achieved, more or less of this demonstration should be given.

The apparatus consisting of a transformer to vacuum tube full-wave rectifier into a conventional filter circuit consisting of chokes and condensers here illustrated, Figures 1 and 2, is still unavailable from the scientific supply houses and must be custom built.[2] All wiring is color-coded. Many binding posts are included in the design so that as many questions as can possibly be raised may also be answered by demonstration. The usual take-off to the oscilloscope is across the load at b.p. 3 and b.p. 4. Porcelain knife switches are incorporated for safety, as well as for ease of manipulation. The demonstrations possible with this apparatus are: (1) alternating-current in-

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[2] Components of the full-wave rectifier filter circuit.
1 Transformer, 250–0–250 v.
2 Chokes, 8 henry, 450 ohm
2 Condensers, electrolytic, 8 mfd., 400 v.
1 Condenser, electrolytic, 16 mfd., 400 v
1 Resistor, 15,000–25,000 ohm, 50 w.
1 Eby socket, 4 prong
1 Type '80 vacuum tube
4 Binding posts, insulated
5 Porcelain miniature knife-switches, s.p.s.t.

put at the binding posts; (2) full-wave rectification; (3) the smoothing action of one or two eight henry chokes only; (4) the effect of one, two, or three condenser sections, 8-16-8 mfd. only; (5) condenser input, one or two sections; (6) choke input, one or two sections; (7) pi-sections, one or two sections. All of these demonstrations are achieved by opening and closing the single-pole knife switches, Figures 3, 4, 5, 6.

As more of the filter circuit is employed, the *vertical amplifier* may be turned up. This should always be announced before the demonstration.

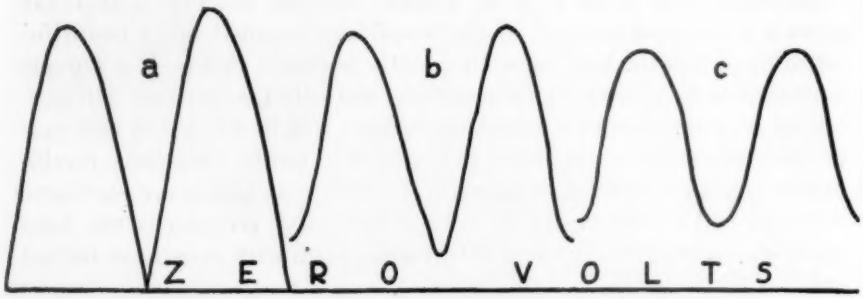


FIG. 3. Filter-action with Chokes Only.
a. Full-wave rectification, 200 v.. Amplifier at 15.
b. One eight-henry choke only, 190 v., Amplifier at 15
c. Two eight-henry chokes, 190 v.

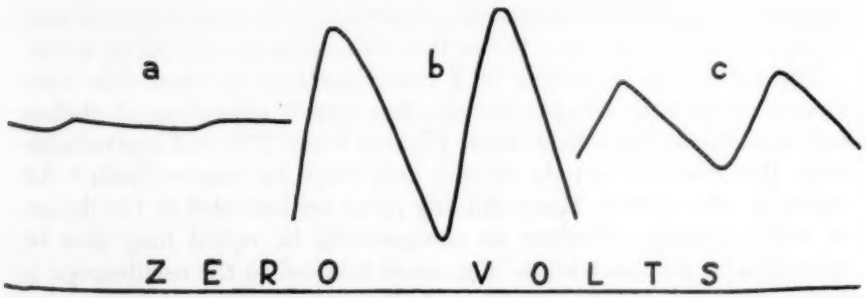


FIG. 4. Filter-action with Condensers Only.
a. One eight mfd. condenser only, 250 v., Amplifier at 15.
b. One eight mfd. condenser only, Amplifier at 50.
c. Two condensers, 8–16 mfd., Amplifier at 50.

*Voltage-Doubler Circuits.* If it is desired to demonstrate this phenomenon, a 25Z5 tube with a resistor ballast to the filament, or a 117Z6 tube connected directly to the 110 v. supply is easily built from the conventional diagram, Figures 7 and 8. The saw-tooth form of the output differs from the sinusoidal full-wave rectification. The voltage-doubler is frequently enough employed to lessen the weight

of semi-portable radios to warrant giving some consideration whether or not to demonstrate this circuit. It can also be used as an inexpensive source of medium range voltages for the laboratory.

## Electrical Resonance

The ultra modern high school physics texts now present, as a preparation to instruction in radio, such terms as inductance, capacitance, reactance, impedance, which will lead up to electrical resonance and tuning. Modern radio service manuals contain ample details of procedures for demonstrations at radio frequencies. The

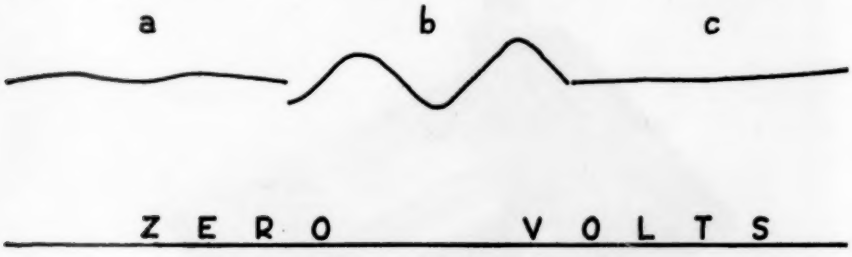


Fig. 5. Filter-action with Choke Input.
a. One section only, 200 v., Amplifier at 15.
b. One section only, Amplifier at 50.
c. Two sections.

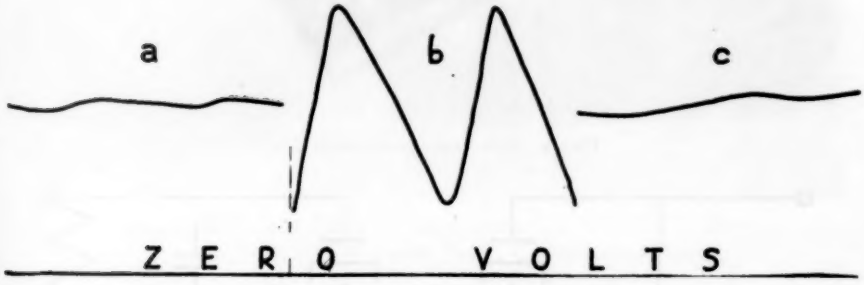


Fig. 6. Filter-action with Condenser Input.
a. One section only, 250 v., Amplifier at 15.
b. One section only, Amplifier at 50.
c. Two sections.

demonstration here detailed, is not at radio frequencies, and therefore requires auxiliary apparatus which will resonate at sixty cycle frequency.

There are four essential parts: (a) a coil of 3000 feet #14 P. E. copper wire wound on a one and five-eighths inch tube. The overall height of the coil with the ends included is ten inches. Its ohmic resistance is seven ohms. The approximate diameter of the coil is five inches. (b) A variable condenser pack consisting of 600 v test sections of 1, 2, 4, 8, and 8 mfd., so constructed that any number from one to

the total of twenty-three mfds. can instantly be connected into the circuit by means of s.p.d.t. switches. (c) A lamp in a mounted socket connected to binding posts; the useful sizes are 100 w., 150 w., and 300 w. These lamps are inserted into the circuit one at a time as visible indicators of the resonance achieved. They also act as auxiliary resistance to the circuit. (d) A solid iron core, one and one-half inches

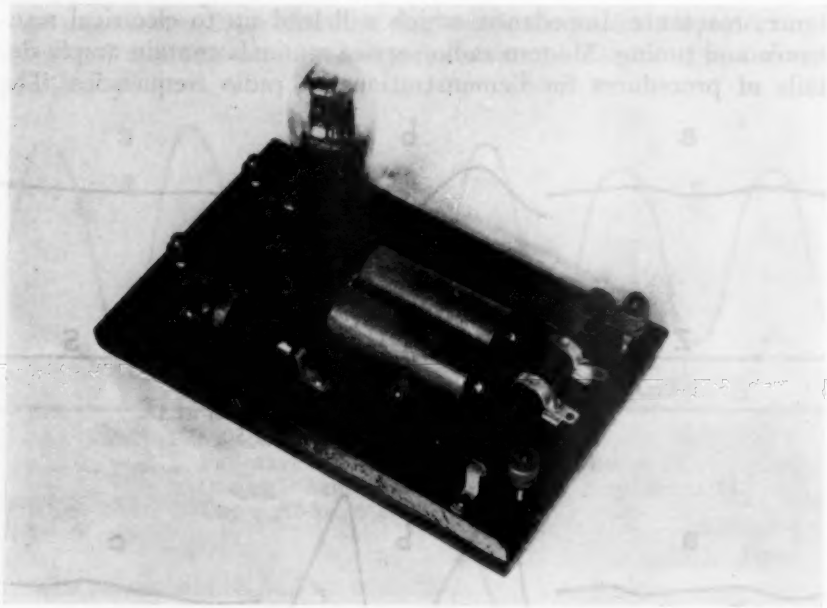

FIG. 7. The Voltage-doubler 25Z5

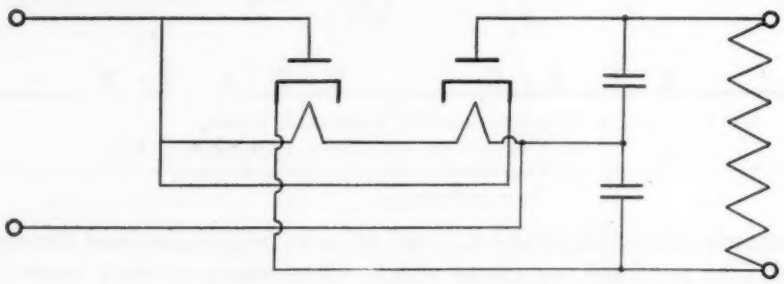

FIG. 8. The Voltage-doubler Circuit for 117Z6

in diameter, ten inches long, ending in a screw hook as a handle. The core is marked in one-inch lengths. It is used in tuning the circuit by varying the inductance. These pieces are suggested in scientific supply house catalogues, Figure 9.

*Tuned Circuit, Series.* In this circuit the resistance (lamp) is placed

between the inductance and the capacitance. Connected to a 60 cycle, 110 v. line, the series tunes broadly at 8 mfd. or more, and five inches of core. Three separate demonstrations seem indicated: one, using lamp brightness as an indicator; another, with A.C. voltmeters of 500 v. range across each of the three components, or at least across the resistance; a third demonstration on the oscilloscope only.

a. *On Sweep Frequency.* Set the *coarse frequency* at 30–150; *test prods* to *vertical amplifier.* Beginning with an in-phase sine image, the resonance curve can be achieved when the *fine frequency* and *sync amp* are carefully adjusted.

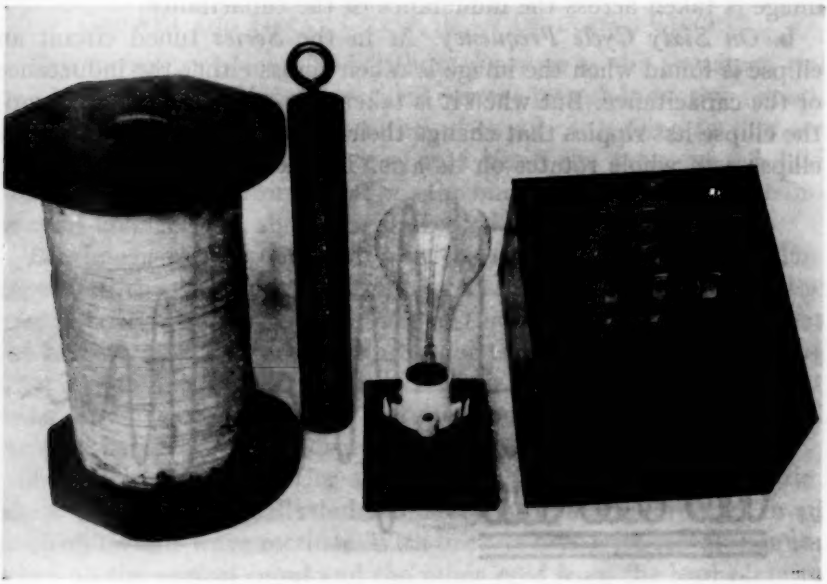

FIG. 9. Resonant Circuit Components.
a. Coil; b. Condenser Pack; c. Resistance (lamp).

b. *On Sixty Cycle Frequency.* Set the *coarse frequency* at *hor. Input amp.; test prods* to *vertical input; test signal to horizontal input.* Both amplifiers are adjusted to give an ellipse at 45° to the horizontal axis and fitting within a square on the oscilloscope's screen. This ellipse turns on its axis and presents its reverse face during tuning through resonance. Such a performance is not easily forgotten, even if its exact meaning is not too clear to the students. The elongation and "standing on its edge" of the ellipse at the point of resonance graphically shows the changed electrical conditions within the circuit.

*Tuned Circuit, Parallel.* In this circuit the inductance and capacitance are in parallel, while the indicator lamp is in series with the wave trap. This demonstration tunes broadly at 18 mfd. and five inches of core. As in the *Series Tuned Circuit* three demonstrations are

indicated: one, using lamp brightness as an indicator; another, with A.C. voltmeters of 150 v. range across the wave trap and also across the resistance (lamp); a third, this demonstration with no meters but with the oscilloscope only.

a. *On Sweep Frequency.* The connections and settings are like those for *Series.* The image shows the nature of the circuit, but it changes less during tuning than in the series resonant circuit, and that whether taken across the inductance or the capacitance. When the *test prods* are across the resistance (lamp) a series of ripples (harmonics) masks the resonant curve. This does not happen when the image is taken across the inductance or the capacitance.

b. *On Sixty Cycle Frequency.* As in the *Series* tuned circuit an ellipse is found when the image is taken across either the inductance or the capacitance. But when it is taken across the resistance (lamp) the ellipse has ripples that change their shape dramatically while the ellipse as a whole rotates on its axis. The demonstration with lamp

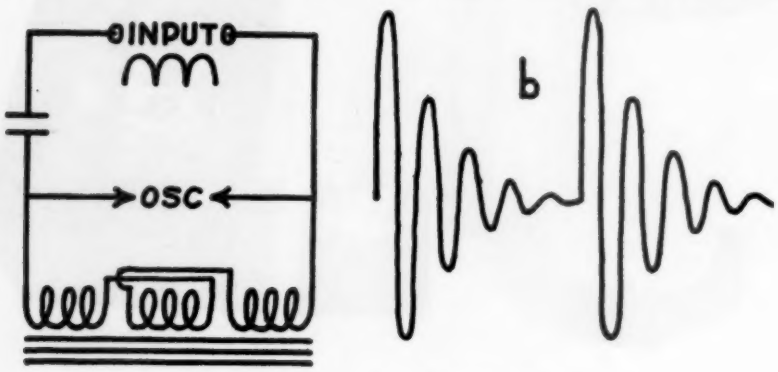


FIG. 10. Dampened Oscillatory Discharge
a. The circuit. b. The wave form.

brightness, varying as it does at the same time that the Lissajou figure changes, may be distracting so that the demonstration should be repeated.

## DAMPENED OSCILLATORY DISCHARGE

To produce those beautifully dampened waves illustrated in physics texts without resorting to radio frequencies requires a special circuit composed of three equal coils in series with a condenser pack. These coils should be in series with the middle one bucking the other two, Figure 10. The common Gilley coils will work quite well. The condenser should be a variable one so that rapid adjustments can readily be made with switches. In this way the image can be adjusted quickly to any desired decrement. A condenser pack with a

range of 1–8 mfd. will prove quite ample. A sharply dampened wave will be found at the lower values of the condenser range, though this will depend of the size of the inductance used. The input for this circuit is a full-wave rectified alternating-current. Any ripples in the input will be faithfully reproduced in the image of the dampened wave. The *test prods* to the oscilloscope are taken across the three coils only. Two dampened waves result, one from each pulse of the rectified current. The image depends on: (a) the inductances; (b) the capacitance; (c) the reversed magnetism of one coil; (d) the purity of the impressed pulse; (e) the impressed voltage.

### Growth and Decay Curve in an Inductive Circuit

This curve can be obtained without recourse to the thyratron circuit by the use of half-wave rectified current into an inductive circuit. The perfect image can be obtained when all controlling factors are well balanced: The inductance should be in the range of 0.3–1.25 henries; the voltage from 15–45 v.; the ohmic resistance low; the impressed voltage form should be unrippled.

The image can be obtained with the *test prods* across the inductance, but the growth curve beginning at the right and reading to the left. Polarity also affects the shape of the image. It is essential that the half-wave rectified current have good form. Such current can be from any source including the electrolytic (lead-aluminum) cell, but using only one of them. If the last mentioned source is used, the cell must be ballasted with sufficient resistance.

*An Alternate Method.* Use a step-down transformer, 2 to 1 ratio, where the resistance ballasted secondary is connected in series to an electrolytic half-wave rectifier. With one *test prod* from the aluminum (plus) to the *vertical input* and the other *prod* from the lead plate to the *ground*, a good pattern of a growth and decay curve is obtained. This curve is also reversed; the growth part is on the right.

### The Transformer

Of the electrical phenomena observable in the transformer the oscilloscope can demonstrate three.

a. *Phase Change.* When demonstrating the shape of the impressed voltage the trace may appear 180° out of phase. This condition may be corrected by connecting the *test signal* to the *synchronizing selector* and switching from *int* to *ext.* With the trace now showing the positive half of the cycle on the left, care must be taken to cross over from left to right and right to left with the *test prods* when making connections on the secondary. Further care must be exercised not to impress on the oscilloscope a voltage higher than its input limits allow.

The phase change can also be demonstrated with the Lissajou figures. For this the *test signal* is connected to the *horizontal input*. The *coarse frequency* is switched to *horizontal input amplifier*. The image in the primary circuit is the usual straight line at 45°, while the image in the secondary tends to assume the nature of a hysteresis curve, though at 135°.

b. *Voltage Change*. It is difficult to say which makes for the better understanding of this phenomenon, a step-up or a step-down transformer. For all practical purposes a two to one ratio seems best, as this requires no resetting of the *vertical amplifier*. When a good image is obtained directly from both the primary and the secondary without recourse to amplification the distrust of a "rigged experiment" is removed.

c. *The Number of Turns*. Four or more equal size coils (Gilley) are mounted on a solid core (rod). The first coil (primary) is ballasted with lamp resistance to the alternating-current supply. The other coils are connected in an open-ended series. The oscilloscope is adjusted for height of image to about one-half inch or more on the primary. Then the *test prods* are transferred to the secondary (series). As one *prod* is moved from one coil to another the image increases in height. These increments of height are not equal as the coils are farther removed from the primary, yet the demonstration is convincing.

## Induction Coils

Some years ago an inquiry appeared in this journal as to what happens in the primary of an induction coil and what is the nature of the current in the secondary. If the coil under investigation is a true Ruhmkorff type with a vibrator and a condenser across the interrupter a very definite answer cannot be had by connecting the oscilloscope directly across the primary. The trace though much obscured by sparking transients will be that of a dampened condenser discharge.

Since the primary circuit is a resonant one composed of inductance and capacitance, it will broadcast. It may even be unnecessary to connect the *test prods* to the primary, but with connections usually clearer patterns are obtained. Polarity also affects the trace.

When the investigation of the phenomenon in the secondary is attempted care must be taken to protect the oscilloscope against the resulting high voltage. This can be economically done by using three wire-wound radio resistors in series across the secondary. The resistances will depend on the voltage in the secondary. In one investigation we found as adequate a series 7000–100–7000 across a 4.5 cm discharge, when the *test prods* were across the 100 ohms. As the pri-

mary pattern will also mask the results of the secondary unless shielding and grounds are used, the image obtained requires a great deal of interpretation.

*The Ford Coil.* The induction coil (interrupter type) used in the Model T with only three connections is not a true Ruhmkorff type. Neither does it give a clear trace which can be easily recognized. This should not discourage the use of this piece of apparatus as a demonstration piece. It just is not a good piece to use on the oscilloscope.

The answer to what happens in the primary without the masking transients resulting from the sparking and the condenser discharge can be had by referring to the previous section on *Growth and Decay Curve in an Inductive Circuit.*

As to what happens in the secondary, use instead of the vibrator-interrupter type a full-wave rectified A.C. into the primary of a transformer. With this source of current flowing into the primary of a pair of Gilley coils or into any transformer, it may be shown on the oscilloscope that the current in the secondary is alternating. If a rippled input current is used, the secondary current will also be overlaid with ripples. This demonstration may also be shown for the telephone transmission line where a change is made from pulsating direct current in the primary to alternating in the secondary.

### Polyphase Currents

Two- and three-phase voltages are at present rarely available for general distribution. Neither is it necessary to produce them in special circuits or apparatus. The images of two- and three-phase voltages can be *simulated* by detuning the sweep circuit. It should be announced to the students that this demonstration is not one of fact, lest their faith in the teacher be undermined by such a subterfuge.

## PART 2. SOUND PHENOMENA

Since almost eighty-seven per cent of human sense knowledge comes through sight and only seven per cent through hearing, this alone would warrant the use of the oscilloscope in teaching sound phenomena.[3]

To make sounds visible on the oscilloscope the microphone and its amplifier are a primary necessity. The importance of this ancillary equipment for successful demonstration must not be underrated, namely the sensitivity of the microphone and the adequacy of the amplifier. There are two kinds of microphone with their amplifiers that should be given consideration: (a) the low impedance type, of which the double-button carbon mike is an example; (b) the high

[3] *The School Executive*, July, 1950, p. 32.

impedance type, of which the crystal mike is the most common.

The double-button carbon microphone is at present not very common, as it has been superceded by the crystal type with its vacuum tube amplifiers. The double-button type, however, has one advantage, the low cost of the whole assembly. Operated on a 22v. "B" battery, it requires only a low to high impedance microphone transformer and a variable rheostat to actuate the oscilloscope, Figures 11

FIG. 11. Double-button Carbon Microphone Input.

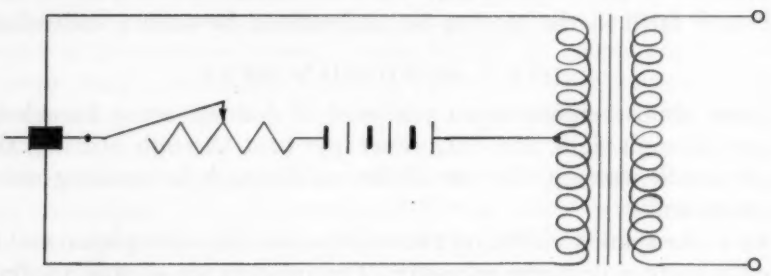

FIG. 12. Circuit for Double-button Carbon Microphone.

and 12. Where other amplifiers are available the double-button carbon microphone is unnecessary.

If the crystal microphone is contemplated it will require two or three vacuum tubes for amplification with a rectifier and filter system to be operated by alternating current. Since many of the sounds are

not very loud, the alternating-current operated amplifiers can easily be fed into small speakers whenever teachers want the sounds to be distinctly audible to the whole class.

### Pitch

The first demonstration of sound is usually both disappointing and confusing to the student. He is told of the differences existing between a transverse wave and a compressional one. Then the tuning fork's trace on the oscilloscope turns out to be a familiar pattern of a transverse wave. Some of this confusion can be eliminated when a companion demonstration of an electrically driven fork's trace on a vibrograph is shown.

A second source of confusion is the fact that when a fork's trace is on the oscilloscope, a higher or lower pitched fork will not give more waves or less, but the oscilloscope must be synchronized to the new frequency. This difficulty can be avoided when octaves alone are first demonstrated without change of synchronization. Later, the frequencies between the octaves can be explained by comparison with the radio which must be tuned to each new station.

Some help in clearing up the confusions can be had by lightly locking in the image of any desired frequency from fork or voice. When a sharp or a flat of the same note is next used the trace veers off to the right or left showing that new synchronization (tuning) is needed.

### Loudness or Intensity

The second property of sound seems to be most easily demonstrated when the definition of half-amplitude on the sine wave is accepted. Massive forks, even pipes (iron or brass), on any suspension when sharply struck give large amplitudes on the oscilloscope, which also do not die down too rapidly.

### Timbre or Quality

Whether done with the human voice or with musical instruments the third characteristic of sound is more interestingly demonstrated than the two previous ones. More than anything else in sound, quality is of interest to glee club, orchestra, and band members.

a. *The Human Voice.* If the microphone is passed from hand to hand, students singing the same note are astounded by the differences in the patterns they produce. It might be well to point out the well-cultivated voice patterns in distinction from the less practiced voices. Soprano, alto, tenor, and bass, singly or in combinations make interesting patterns.

b. *Instrumental Quality.* Student members of band, glee club, and orchestra attending physics classes are proud to contribute to these

demonstrations. Even *outsiders* might be invited to perform. A series of different instruments might be gone over twice. Then compare pairs of instruments sounding the same note: (a) the differences between string and wind instruments; (b) the differences between two brass instruments; (c) the differences between brass and woodwind instruments can be shown. Trios and quintets can also be shown to advantage.

c. *Vowel Sounds.* Something rarely realized by the uninitiated is the vast differences in the vowels, such as in the A. Even strong national characteristic differences can thus be made visible. But this requires a large screen and amplification.

### Noise

As a new pattern, noise hardly needs emphasis. Noise patterns frequently are a nuisance in sound demonstrations. But it would be well to distinguish between noise patterns resulting from the ruffling of papers, the crushing of cellophane, and the electric buzzer's rattle. Even explosive noises such as the tramping of feet or the clash of porcelain dishes are interesting. The change in noise levels, when the school windows are open and then closed, are also appreciated when shown. The number of different patterns is limited only by the ingenuity of the teacher.

### Sympathetic Vibrations

When this phenomenon is demonstrated using massive forks mounted on wood resonators, the result is at times disappointing due to the high noise level. The transfer of energy from one fork to another over a distance of a few feet is small. The two usual demonstrations, that of a tissue paper rider to be dislodged or a pith ball on a silk thread to be disturbed, are not dramatic. Neither is a microphone of much help unless it is a contact mike with an adequate amplifier. The experiment might be repeated with a slight weight added to the exciting fork to show that the transfer of energy is now notably less or non-existent.

### Resonant Air Columns

a. *Closed Air Column.* The usual method of a glass tube telescoped into a hydrometer jar containing water is loud enough to be convincing. But with the microphone and through the oscilloscope the visible increase in amplitude will erase any doubts.

b. *Open Air Column.* As a preparation and introduction to the *Laws of Pipes* the resonance of open air columns with an adjustable paper sleeve over a glass tube should be demonstrated. The obvious comparison of lengths should not be neglected.

### Interference

To take this demonstration out of the class of those for the individual and make it for all the class, the usual method of slowly rotating a tuning fork over a resonant quarter-wave length air column can be used. The oscilloscope will give visible proof of the audible phenomenon.

Rotating a vibrating tuning fork of any frequency near a microphone will produce the same interference trace at the proper positions.

### Beats

Use the massive tuning forks with their trace adjusted as a first step. When one of these forks is lightly weighted with putty or modelling clay, a one per second beat is obtained. As more weight is added, the beats increase in frequency till a most unpleasant sensation is obtained. The oscilloscope faithfully follows these beats by its pulses.

### Harmony and Modulation

Musics students who have had some instruction in the theory of harmony achieve a better comprehension of the concepts of interval, thirds, fifths, triads, tonic, dominant, subdominant, etc., when these are demonstrated on the oscilloscope. Such a demonstration requires an octave of tuning forks, 256–512 v.p.s., with possibly also a 1024 v.p.s. fork. The advantage accruing from the use of forks is that the input is of a pure tone. Best results seem to come when the tines of the forks are held parallel to each other, and at approximately the same distance from the microphone.

If one of the forks is rotated for interference, the other fork's trace only will be visible. By this method the inputs can be demonstrated individually and in pairs.

At times a perfect pattern of modulation of the higher frequency by the lower is obtained (one or two beats in a standing wave pattern). Such a combination of forks is that of an A, 426.7 v.p.s. and B, 480.

The number and complexity of the demonstrations must be determined by student interest, the time and the equipment available.

### Laws of Vibrating Strings

A most valuable technique using the oscilloscope with an amplifier and speaker was reported in School Science and Mathematics by R. C. Grubbs[4] to demonstrate the laws of vibrating strings. He reported that the law of length and the law of tension were verified on the oscilloscope by his technique. It is presumed that the law of mass

[4] Grubbs, R. C., "Demonstrations in High School Physics." School Science and Mathematics, XLVIII March, 1948, p. 199–201.

per unit length could also be verified easily with wires of double and triple diameters and of the same materials.

### Laws of Pipes

Most demonstrations in this area are of sufficient loudness to be convincing. This fact together with the transparency of glass pipes makes the use of a secondary demonstration by the oscilloscope seem superfluous. There might be an exception in the case of the open and closed pipes of the same length sounding their fundamental frequency.

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## NOTE ON A STUDENT'S PROOF

Ray Jurgensen
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The plane geometry textbook used here presents an eleven step proof of the theorem *If two angles of a triangle are equal, the sides opposite those angles are equal.* The proof involves two auxiliary lines, a set of overlapping congruent triangles, and then another set of overlapping congruent triangles.

Frank A. Kellogg, who comes to Culver from Longview, Washington, thought that there should be a simpler proof. The proof which he devised seems unusually interesting, and it may be new to enough teachers to warrant its appearance in this periodical. Kellogg's argument was essentially as follows:

Given: $\angle A = \angle B$
To Prove: $AC = BC$
Proof: $\angle A = \angle B$
$AB = BA$
$\angle B = \angle A$
$\Delta ABC \cong \Delta BAC$
$AC = BC$

### COMMENT BY THE MATHEMATICS EDITOR

A very commonly encountered proof uses the bisector of the vertex angle. Let $CD$, the bisector of angle $C$, meet $AB$ in $D$. Then in triangles, $BCD$, $ACD$, $\angle BCD = \angle ACD$, $\angle A = \angle B$, Side $CD$ is common; hence in the congruent triangles $ACD$ and $BCD$, $AD = BC$.

Some teachers will question whether or not it is legitimate to prove a theorem by proving a triangle congruent to itself. In another form, Kellogg's proof could be stated; "Construct triangle $A'B'C'$ equal to $ABC$. Then by superposition, placing point $B$ on point $A'$, etc., these may be proved congruent.

Cecil B. Reed
University of Wichita

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Have you paid your subscription for 1951? Cleveland is our convention city this year.

# INSIDE THE ATOM

## III. PROVING EINSTEIN'S THEORY

BARBARA R. BALZER

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Several years ago the cover of *Time Magazine* had on it an equation: $E=mc^2$. This equation is a part of Dr. Albert Einstein's theory of relativity. Mr. Einstein is very good at setting down big theories in little equations. In the equation: $E=mc^2$, $m$ stands for *mass*. The mass of a body is expressed in units of weight like pounds or grams. But the mass of a body does not vary when the body is carried to the top of a mountain where gravity will pull on it less, even though a scale weighing it on the top of a mountain would record a different weight than the weight it had recorded at a lower place. A physicist would say that the mass of a certain body is the amount that that body resists being *accelerated* or made to move faster. We know that the push required to make a heavy object speed up is greater than the push needed to speed up a light object.

We now know what $m$ stands for in the equation. We still have $E$ and $c^2$ to account for. $c$ represents the velocity of light—$3\times10^{10}$ centimeters per second; $c^2$, then, is this number multiplied by itself. $E$ is what is called the energy equivalence of the mass. It stands for the amount of energy that would be freed if a certain mass could be destroyed as mass, but changed into energy. According to this equation, mass and energy are really forms of the same thing. Mass can be turned into energy or energy into mass. If a certain quantity of mass could be destroyed, a definite amount of energy would be available in some form.

Mr. Einstein's theory suggests that a very large amount of energy can be obtained from a very small mass. The energy equivalence of an object of a certain mass is the mass of an object multiplied by the speed of light squared, or mass times $3\times10^{10}$ centimeters per second times $3\times10^{10}$ centimeters per second. To illustrate this, let us imagine that we could destroy the mass of something weighing one gram, something the size and weight of one of the small metal weights used on the balances in the laboratory. This piece of metal, about the size of a dried pea, would release enough energy to propel the largest battleship once around the world.

Now let us turn to the Cavendish Laboratory in England. Lord Ernest Rutherford, who was directing research there in 1930, had his men begin the construction of a huge machine to speed up the particles used as bullets in the disintegration experiments such as the

one we have already discussed, the one in which Lord Rutherford changed nitrogen into oxygen by shooting alpha particle bullets at it. The machine which Rutherford had instructed his men to build was going to be able to generate a million volts of electrical potential. Rutherford was going to use the machine to speed up hydrogen nuclei, protons, and to cause them to strike known substances. He hoped to produce new kinds of disintegrations by using these protons rather than alpha particles.

Rutherford became impatient when work on the machine proceeded very slowly. He suggested to two of his scientists, Cockroft and Walton, that they try shooting protons at materials at lower speeds than those which would be achieved by the million volt machines. In 1932, Cockroft and Walton announced that they had successfully disintegrated lithium atoms using protons speeded up by machines with the power of only 150,000 volts.

Their "proton gun" was a tube filled with hydrogen gas. The electrons given off by a hot filament at one end of the tube would *ionize* many atoms of the hydrogen gas, that is, they would divide the hydrogen atoms into electrons and protons. The protons with their positive charges would be made to move faster and faster toward the other end of the tube. The 150,000 volts of the machine would cause them to accelerate, or speed up. A stream of fast-moving protons would come out of the end of the "gun" and bombard a target consisting of lithium metal. Cockroft and Walton observed and measured the alpha particles coming off the lithium metal with an energy seventy times that of the energy of the proton bullets. This meant that a tremendous amount of atomic energy was being released.

Some of the protons had evidently entered the nuclei of some of the lithium atoms, producing nuclei of beryllium. Being unstable, each beryllium nucleus would split into two helium nuclei, or alpha particles, which would fly away from each other with great energy. The measured energy of each one is seventy times that of the energy of the proton bullet which caused the disintegration; thus, the total energy produced by the change in the lithium nucleus would be equal to one hundred and forty times that of the proton bullet.

According to the calculations of Cockroft and Walton, there was a slight loss in mass in the reaction—in other words, the two helium nuclei were a little lighter than the original lithium nucleus. When they compared the loss in mass in the nuclear change to the gain in energy, they discovered that their results agreed almost perfectly with the results that could be predicted from Einstein's equation: $E=mc^2$. They had proved that that part of Einstein's theory of relativity was true!

# DEVELOPING CRITICAL THINKING THROUGH ELEMENTARY SCIENCE

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Can elementary school students think critically?

If we accept the term "critical thinking" in its broadest sense, there seems to be little doubt in the minds of many elementary school teachers and parents that they can.

Should we try to develop critical thinking during elementary science activities? Any list of present day educational objectives has critical thinking named in one way or another. Science should prove a fertile field in which to strive toward this objective.

How to develop critical thinking is not so easy to determine. It would seem that separate units attempting to develop this ability do not accomplish the desired result. Further, this ability is not something that can be taught for three weeks and then forgotten: it should be a part of each and every unit plan. Again, it is not easy for one always to recognize and utilize the opportunities presented to develop critical thinking during a normal classroom period.

In conducting a class for teachers in elementary science, the writer had the pleasure of participating with the members in pointing out possible avenues of presentation of science materials that could lead toward critical thinking. The class entered into and accepted the spirit of mutual criticism with such objectivity that the writer feels they will not object to his recounting some of their experiences that occurred during the semester.

1. An elementary school teacher was demonstrating the teaching of the thermometer. She wished to show the boiling and freezing points of water. She placed a thermometer in a glass containing ice and water and then to "hasten the process," she added salt to the mixture. When the thermometer fell to 32°F she withdrew the thermometer and continued with the second part of the demonstration. How fortunate for her that she did not leave the thermometer in the mixture longer; some youngster might have noticed the thermometer continued to drop below 32°F and would have wanted to know why.

In placing the thermometer in boiling water, she admitted the reading was less than 212°F but passed it off as being close enough and said the experiment "proved" that water boiled at 212°F. Perhaps the concept of boiling temperature as a function of atmospheric pressure was too difficult for the grade level, but it is an error to pass over seemingly small discrepancies as being inconsequential. The

history of science has shown that at times it is the small differences in results that provide a beginning to whole new concepts.

2. In demonstrating the making of a compass, one student stroked a needle 20 times over one pole of a magnet, stuck the magnetized needle through a cork and finally floated the cork in water contained in a metal pan. The cork and needle migrated to one side of the pan. When asked why this occurred, the student said she guessed it was because the table was not level! In the discussion that followed this explanation, the phrase "Water seeks its own level" was used. To many, this phrase may have meaning; if so, it is probably because of a background of knowledge and experience. But to the uninformed, it is doubtful if the phrase offers much real explanation. It is similar to saying, "Nature abhors a vacuum" as an explanation for some phenomenon due to atmospheric pressure. How often do we teachers allow students to put some name or tag on a phenomenon in lieu of a good explanation of "why?"

Another member of the class related how he had performed a similar experiment by floating a greased needle on water. He explained that he had had difficulty in floating the needle until he used a pan with a greater depth of water which gave more pressure to support the needle!

Incidentally, the demonstrator said to stroke the needle over the magnet *20 times*. Was there something particularly significant about the exact number 20? She correctly reasoned that there was not, but said she had repeated the directions from a book. Seemingly simple direct statements may have entirely different connotations to the student. Within the past week of this writing, the author's son recounted how this experiment had been performed in his school, again with *20* strokes. (Apparently some book has done a good job of emphasizing the number *20*.) Such a critical analysis is not splitting hairs; entirely incorrect concepts may be formulated in the minds of students by the use of unthinking words and phrases. To further illustrate: when the next teacher used the phrase "fire-formed" rocks (certainly a commonly used term) one member of the class wanted to know how rocks could be *made from fire*.

3. Part of the next demonstration was to place some acid on various rocks and note that the only one of the samples used that foamed was limestone. Therefore, anything that foams when acid is placed upon it is limestone? A rather logical sounding conclusion for some youngsters.

4. To "prove" that air is $\frac{1}{5}$ oxygen, a burning candle was set up in a pan of water and a glass inverted over the candle with the rim under the water. The water was to rise up within the glass $\frac{1}{5}$ of the

way and thus it would be concluded that $\frac{1}{5}$ of the air is oxygen. How often have we teachers set out to "prove" a point by a single experiment with all kinds of variables and assumptions? Needless to say, there is more than one apparently valid explanation that could be given on the basis of such limited data.

Actually, the measured distance was appreciably greater than $\frac{1}{5}$, but the difference was about to be written off as an ever present experimental error. One alert member pointed out that the volume of the candle must be taken into account, and another wondered if the different diameters at the top and bottom of the glass affected the vertical height to which the water rose.

It is interesting to note that in the discussion of this experiment such statements were used as "the air condensed"; "the air was used up"; "the air was overheated"; "a vacuum was made by fire":—highly rationally sounding mumbo-jumbo but showing little understanding of what took place and why.

5. To illustrate how matter expands when heated, one member explained that open strips were left between slabs of concrete on a highway so that the tar beneath the highway would have a place to expand when heated. This might appear as an excusable error due to lack of technical knowledge, but actually it ignores the expansion of the concrete which should be recognized as a factor.

6. *Thirty* turns of insulated wire was wrapped around a large nail and the wire connected to a dry cell. (Again, a definite number, no more, no less.) In explaining the electromagnet, the student stated that it was necessary to use insulated wire to "keep in the magnetism," and, "of course, you could not get the magnetism without using an iron nail." Such faulty thinking may be simply the lack of sufficient knowledge of factual information, but it is poor critical thinking when we allow ourselves to indulge in unwarranted explanations.

Later this same student read in a leading elementary textbook that if bare copper wire were used in making an electromagnet, it would not pick up a single tack. When she tried it, she found it picked up not only one but several tacks! Perhaps, even authorities need to be more rigorous in their statements.

The few illustrations above attempt to point out how some elementary school teachers were able to help each other in realizing and appreciating the opportunities to develop critical thinking through elementary science. With an awareness and alertness to these opportunities, the teacher will be in a much better position to aid her pupils to think critically.

# BIOLOGICAL DOUBLETALK

NORMAN LOWENSTEIN
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Technical terms are an indispensable part of every science. They are needed to make important distinctions as well as to express succinctly complex ideas. However, on occasion, confusing terminology, misnomers, and downright "boners" have been introduced into the literature of a science. These tend to be perpetuated through the sheer inertia of textbook writers and examination makers. If, as one candid student put it, "osmosis is confusion through a membrane," it sometimes seems that science itself is "confusion through a textbook."

A few examples will serve to illustrate this situation in the field of biology:

1. *Sexual reproduction*, as used in many a textbook, includes conjugation in spite of the fact that the author himself may warn the student that there are no sexes in conjugation! Why not include both isogamy and heterogamy under the general title of "gametal reproduction," reserving the term "sexual reproduction" for heterogamy? The only alternative is to call the active cell in isogamy a male gamete and the passive cell a female gamete.

2. *Conjugation* is still used to refer both to isogamy in certain Algae and molds and to the far different and more complex process of endomixis or rejuvenation in certain Protozoa such as the Paramecium. The term should be restricted to one or the other process or else dropped entirely from the biological dictionary.

3. *Incomplete dominance* is an example of what might be called a logical monstrosity. Even a high school student of average intelligence can see that there is either dominance or no dominance except in cases where modifying genes enter the picture. The term "blending inheritance" is certainly far better if it is clearly understood that the mosaic hybrid only appears to be a blend.

4. *Budding* is used to designate three quite different processes; namely, the outgrowth of a daughter cell in yeast, asexual reproduction in certain Coelenterates such as Hydra, and the growth of young leaves and flowers in complex plants. New terms are needed for at least two of these processes.

5. *Tropism* is used loosely by some authors to designate a reaction in any organism in which there is a directional orientation to a stimulus. Thus, the movement of fruit flies toward light would be called a phototropism. At the same time, the term "reflex," as used by some textbooks, includes all unlearned reactions, even those of a Protozoan. This unfortunate confusion in terminology might, perhaps, be avoided if the term "tropism" were restricted to reactions of organisms with-

out a nervous system and the term "reflex" to inborn reactions of animals with a nervous system.

6. *"Purity" of gametes*—The terms "pure" and "hybrid" have meaning only when employed to describe the homozygous and heterozygous condition, respectively, of a zygote or the individual which develops from a zygote. When applied to a sperm or an unfertilized egg cell, the word "pure" is just as inappropriate as the word "hybrid." Even if these terms could be so used, it simply is not true that all gametes must be "pure." In the case of a character determined by two or more sets of genes, a gamete might easily contain two opposite genes. Would it then be a "hybrid" gamete?

7. *Respiration* is used to refer to the process of oxidation within the cell as well as to the taking in of oxygen and the release of carbon dioxide by the entire organism. Sometimes, it is also employed as a general term to include both of these processes. To avoid confusion, it might be wise to restrict this term to one of these three meanings.

8. *Mendel's "Law" of Dominance*—Anyone who has taken the trouble to read his original paper knows that Mendel never proclaimed dominance to be a universal phenomenon. In fact, he specifically called attention to the fact that some plant hybrids do show intermediate characteristics. He certainly did not use the term "Law" with reference to dominance which, after all, he studied in only one plant, the garden pea. Whoever started this unfounded rumor should apologize, at long last, to the shade of one of the most careful investigators who ever lived. Textbook writers and examination concocters, please note!

9. *Man did not descend from an ape or monkey*—If he did not, then what on earth did he descend from—a bald eagle? Of course, Man did not come from a modern ape or monkey any more than the ape or monkey came from Man. Nevertheless, the "common ancestor" of Man and the modern apes must have been itself some kind of ancient ape and the "common ancestor" of Man, the modern apes, and the modern monkeys was some kind of ancient lemuroid. Why hedge about this? The apes, monkeys, and lemurs won't be offended! Or would they, if they knew?

10. *Evolution is development from the simple to the complex*—If the term "evolution" is used in its usual, general sense, this proposition, which is widely current, is a gross oversimplification. While it is true that relatively simple organisms appeared on the earth before complex forms, it is also true that, in many instances, a subsequent degeneration of complex types into simpler forms has occurred. Some well-known examples of this include the sacculina, slime mold, tapeworm and even the lowly ameba. Some authors attempt to avoid this difficulty by restricting the term "evolution" to development from

the simple to the complex and using a new term "devolution" to describe the degeneration of complex to simpler forms.

11. *Origin of the first living thing*—Some textbook writers assert that this problem is unsolvable despite the fact that simple logic compels us to infer that, since the first living thing could not have come from a preceding living thing, it must have originated from non-living matter. All that remains in doubt is the exact sequence in the series of chemical reactions which must have taken place during the development of protoplasm from lifeless material. That such a transformation can take place is revealed by the very existence of green plants which are constantly changing water, carbon dioxide, nitrates, phosphates, and sulfates into protoplasm.

12. *Is the virus alive?*—This question is just as meaningless as the query, "Is twilight day or night?" Since nearly all processes in the universe are continuous, there will always be in-between stages which cannot be fitted into neat categories.

It might be well worthwhile if every science teacher would take the trouble to jot down a list of technical terms which he has found to be inadequate, ambiguous, misleading or confusing. Perhaps, if we could pool our peeves through the medium of a national publication such as "SCHOOL SCIENCE AND MATHEMATICS," we may eventually succeed in impressing some of the textbook writers and examination makers. In any event, we may be able to help one another to eliminate in the classroom some of the "scientific" doubletalk which plagues us and our poor, unsuspecting students.

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## LOW TEMPERATURE AT WISCONSIN

Tucked away in a basement corner of Sterling hall at the University of Wisconsin is the coldest spot in the state and one of the most frigid in the world.

It's no accident that temperatures there frequently fall to about 456 degrees below zero, Fahrenheit. University physicists are working with a new apparatus, technically called a helium cryostat, which creates low temperatures by liquefying helium gas.

What the physicists call low temperature research is one of the prominent areas of study in physics. Although overshadowed in the public press during recent years by nuclear physics, its contributions to scientific knowledge are becoming increasingly important. In 1949 the Nobel prize in chemistry was awarded for low temperature research.

Liquefied gases are one of the tools used by physicists to ferret out the fundamental laws of nature. At room temperature, molecules of matter are in such rapid motion that it is difficult to obtain accurate information on molecular behavior.

Molecular movement is slowed down, however, when matter is cooled by immersing it in extremely cold liquefied gases. When the temperature approaches absolute zero, or 273 degrees below zero centigrade, the molecules almost stop moving and can be studied more easily.

## EASTERN ASSOCIATION OF PHYSICS TEACHERS
## ONE HUNDRED SEVENTY-THIRD MEETING

Saturday, Oct. 8, 1949

United States Naval Air Station, Squantum, Massachusetts

10:00 A.M. Greetings—Capt. John P. Fitzsimonds or an appointed officer.

10:15 A.M. Ground Training School Tour, Demonstrations, and Lectures.
Aviation mechanics instruction,
Motion Picture in color—"Bikini,"
Motion Picture—"Weather at War,"
Demonstration in sound room—Air combat with sound if time permits,
The jet engine.

12:00 Noon Navy Chow, buses to the mess hall, cost about 60 cents.

1:00 P.M. Aircraft Repair Shop Tour, Demonstrations and Lectures.
Riveting
Welding
Parachute packing
Installation of aircraft engines
Electronic shop
Ground Control Approach movie and a possible demonstration.
Movie—"The Berlin Air-lift"

3:30 P.M. Short business meeting.
Buses will return us to the main gate.

To reach the Squantum Naval Air Base:

By auto: From South Station in Boston, Summer Street going south-east one block, turn right and follow the main line of traffic on the Old Colony Parkway, continue about six miles to the traffic circle, continue and cross the bridge over the Neponset River, turn left on Quincy Street, Base is on the left about one mile. Tell the sentry that you are Eastern Association of Physics Teachers, enter the Base, go to the parking area indicated, stay in or near the cars.

By bus and what have you: MTA to Fields Corner, bus to Quincy but get off at Atlantic, bus from Atlantic to Squantum, get off at the entrance to the Base.

Bus transportation at the Base is free.

## REPORT OF THE ONE HUNDRED SEVENTY-THIRD MEETING OF THE E.A.P.T. HELD AT THE SQUANTUM NAVAL AIR STATION, SATURDAY, OCTOBER 8, 1949

The meeting of the E.A.P.T. at the United States Naval Air Station at Squantum, Massachusetts was opened promptly at 10:00 A.M. by the president, Mr. Everett Learnard. The president called upon Mr. Carl Johnson of Worcester for an informal report on the health of our Apparatus Committee Chairman, Mr. W. Roscoe Fletcher of Worcester, Massachusetts. At the suggestion of Mr. Johnson, some 50 members signed a "get well" card. The card was posted at the Base.

Our president read some communications which he had had with the other Science Teachers' organizations: The New England Biology Teachers' Association, and The New England Chemistry Teachers' Associations relative to the dates of the several meetings. It has been planned to schedule all the meetings of the E.A.P.T. and the Biology and Chemistry Associations so that there are to be

no conflicts. A motion from the floor for such a schedule of dates was made and seconded. The voting in favor was unanimous.

At 10:15 A.M. the meeting was turned over to your secretary-treasurer, who, in cooperation with Lt. Goshhorn of the Base, made the necessary plans for the meeting. The lieutenant was introduced to welcome the E.A.P.T. in the absence of Capt. John P. Fitzsimonds. Lt. Goshhorn told us that the Captain thought that this meeting was a "grand idea" for the Navy has the same job at the Base that the teachers have in the classroom and that is teaching. He jokingly told us that in addition to much technical training and teaching, some of us may have noticed the "boys" outside the building in which we were meeting. They belong to the "Landscape Class" and they were learning to Police the Area. This seemed to mean that they were learning to keep the place neat and clean.

*History of Squantum*

After a short message of welcome relayed from the Captain and direct from the lieutenant, the Officer of the Day, he gave us a short history of Squantum.

The first air meet of our country was held here on Sept. 13th, 1910. (Your author lived next door to Squantum at this early time and he recalls seeing the planes from the meet which flew "little end first.")

The Victory Motor plant was built here in 1917. It is not standing today due to a fire in 1927.

In 1923, the present Admiral R. E. Byrd was instrumental in having the locality set aside and organized as a Naval Air Reserve Base.

In 1936, the status was changed to a regular air base.

In 1941, it became an Emergency Base with Navy status.

The field was used in 1942 by the British for their submarine spotting planes.

The field was returned to Reserve Status in 1946.

There are 35 officers and 500 active men stationed here as station keepers. Five hundred officers and 1500 enlisted men serve two days per week. Some 3000 men are trained here per year and take part in a two week active duty "hitch" each summer. The field provides instruction in all phases of navy aviation related to both reciprocation engines and jet engines.

Two other missions are fulfilled by the base today: a base for the air force of the navy and an emergency aid to all aviation.

*Tour of the Station*

The first stop on the tour was a visit to one of the many projection rooms to view the two color movies: "Operation Crossroads," and "Science Through Photography." The story of the nuclear bomb was well told with fine photography. There were many unusual and remarkable shots. The color was first quality. The story of photography's aid to science is an absorbing and very informative film. The navy has these films and many more which are available through proper channels. These films are far better than the usual industrial advertising films which are much used as educational movies.

From the projection room, we were taken to the jet engine lecture room where Seaman Goldstein lectured and answered questions for about one hour about the jet engine. The following seemed the most important:

There is only one major moving part, the main shaft. There are small accessory moving parts in the accessory section: starter, generator, tachometer, fuel pump, lubrication pump, etc.

There are four sections: accessory section, compression-diffusion section, combustion section, and exhaust section.

The engine operates because of Newton's third law. The thrust is derived from the difference in pressure. Bernouilli principle is used in a Venturi for both the fuel and the atmospheric gases.

A toy balloon was used to show the action-reaction principle. The engine is called a jet unit.

The unit must be started on the ground by means of an auxiliary starter. The

current for the starter is about 1800 amperes. The engine starts at or above 2000 revolutions per minute.

Air goes from the compression-diffusion section to the combustion section.

There are ten combustion chambers.

The fuel enters through the fuel manifolds about one third the distance back in the combustion chamber.

All spark plugs are in operation at the start.

Exhaust gases hit the turbine or bucket wheel which pumps air into the front of the engine.

The blast of the hot gases go out the rear port into the atmosphere.

After burners are used near the exit port to make use of some of the fuel which is still unburned. Twenty to thirty per cent more thrust is thus realized.

The fuel consumption for the jet is high, in fact about 500 gallons per hour. At high altitudes, there is a 30 to 50 percent fuel saving for equal mileage.

Quite high temperatures are realized with this high rate of fuel use in the combustion chamber. Three thousand degrees Fahrenheit is common. The blades of the rotating element creep because of the high temperature and the centrifugal force, 16,000 revolutions per minute. The engine can coast as slowly as 2000 rpm by cutting the fuel use to a very low value.

The present engines provide some 6000 pounds thrust at the speed of over 600 miles per hour.

The rear bearing and the oil for lubrication present some special cooling problems. Scoops in the air stream provide the cooling mechanism. Because of the extreme velocities, the plane itself must be cooled. Air streams cool the vital sections.

There are times that the high velocity of the ship together with faulty mechanisms or faulty handling causes a "blow-out" of the burning fuel. When this happens, the engine is flushed with air after turning the fuel off, the air-start switch is engaged and the fuel turned on. The pilot hopes for a start.

The fuel used in the jet is high octane gasoline in the Navy aircraft, the Army uses kerosene.

An actual jet unit was used during the lecture. The unit was set in a portion of a nacelle. Important parts of the jet unit were cut away to show the operation more clearly.

*Classrooms*

The members of the E.A.P.T. were next escorted on a tour of the rooms used as the school. They visited the Link Trainer room. Several of the "ships" were in operation. Other rooms: lecture halls, demonstration rooms, mock-up rooms, film library, sound and silent projector storage rooms, and the technical material library were visited. At each stop there was a question and answer period.

*Navy Mess*

Just before noon, two buses were provided to transport the members of the E.A.P.T. to the BOQ, bachelor officers' quarters, for officers' mess. All were provided either a complete meal, a lunch, or just a snack that was most graciously served. The food was the best, it was standard officers' mess. The seamen receive the same high quality food on a stainless steel compartment tray. The prices pleased all no end.

*Electronics Room*

After a rest and a chance to smoke in the officers' lounge, the members of the E.A.P.T. proceeded to one of the large hangers, one end of which had specialized rooms. The electronics room was visited first. There, surprisingly enough, a former pupil of one of the visitors lectured and demonstrated seemingly numberless pieces of apparatus. The following seemed to be of most interest to the E.A.P.T. Members.

Low, middle, and high frequency receivers and transmitters.

Gear operation of the many controls with no back-lash.
Radar transmitter and receiver—demonstration units were in operation.
Homing devices.
IFF—identification, friend, or foe.
Transponder.
Oscillators.
Synchroscopes.
Wavemeters.

*Generator Test Stand*

The generator test stand is operated by a 20 horse power constant speed motor. There are coupling mechanisms provided by means of which any type or types (up to capacity) of generator may be most easily driven for testing purposes.

*Parachute Loft*

A visit to the parachute loft emphasized the care in both the storing and the packing of silk and nylon 'chutes. The chute you pack may be your own, while not actually in print on signs, is certainly known by all the caretakers and packers.

Twenty-four lines of silk or nylon, capable of supporting nearly half a ton at the top to 70 square yards of silk or nylon. The cloth in the parachute must pass a 40 pounds per square inch test. The group was told that the rate of fall is about 18 to 20 feet per second, or the terminal velocity is about the same as a jump from a ten foot wall. The parachutes are stored with moth flakes not because of the possible insect damage but because the vapors from the flakes, in leaving the storage bundle, prevent the entrance of water vapor.

*Other Visits*

The instrument test shop, the engine mount shop, the general repair shop, and the welding shop were visited in turn. At each shop, a navy man and in one case a group of navy men talked about the particular shop, answered questions and where possible, demonstrated the machines or gear at hand.

*Berlin Air Lift* and *Ground Controlled Approach*

The members were taken by bus to one of the educational movie projection rooms. They were shown two related movies: "The Berlin Air Lift" and "Ground Controlled Approach." Both these films showed the remarkable manner in which the technology of science has been applied to the help of man. The apparatus for Ground Controlled Approach was in use and it could not be seen or demonstrated.

At the termination of the movies, Lt. Goshhorn spoke briefly again of how happy both he and his superior officers were because the E.A.P.T. was "aboard." It was the opinion of many that this meeting was a high point in E.A.P.T. history. The author, your secretary, thanks the many who expressed much appreciation of the meeting. The author is much pleased but hastens to say that your Navy did the work.

The day was so full that there was no time for the apparatus committee to report. It was suggested that a large portion of some future meeting be given over to the neglected subject.

## REPORT OF ONE HUNDRED SEVENTY-FOURTH MEETING OF THE E.A.P.T. HELD AT NORTH EASTERN UNIVERSITY, BOSTON, MASSACHUSETTS, DEC. 3, 1949, A JOINT MEETING WITH THE BIOLOGY AND CHEMISTRY ASSOCIATIONS

The morning sessions were exclusively in the fields of Biology and Chemistry. It is not reported.

The afternoon meeting was a most interesting visit to the WNAC-TV Transmitter. The projection room, control room, camera room, and shading room were

visited. In each room an expert in the field, explained the mechanisms present. There was a question and answer period in each of the rooms.

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# PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

*State Teachers College, Kirksville, Missouri*

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.*

*All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor* should have the author's name introducing the problem or solution *as on the following pages.*

*The editor of the department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.*

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## SOLUTIONS AND PROBLEMS

**Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.**

**1. Drawings in India ink should be on a separate page from the solution.**

**2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.**

**3. In general when several solutions are correct, the one submitted in the best form will be used.**

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### Late Solutions

**2205, 2206, 2208, 2203.** *Marie A. Moore, St. Louis, Missouri.*

**2209.** *Proposed by William W. Johnson, Cleveland, Ohio.*

A horizontal cylindrical tank is 72 inches long, with a diameter of 15 inches. The ends are cones with altitude of 7.5 inches. Find the volume of the combined solid if the water in the cylinder is 8 inches deep.

*Solution by V. C. Bailey, Evansville, Indiana*

Find the volume of the entire tank and then subtract the volumes of the unfilled portions of the cones and of the cylinder.

To find the volume of the unfilled portion of one cone, let the $Z$-axis be the axis of the cone and let the base of the cone rest on the $XY$-plane.

The equation of the cone is

$$x^2+y^2=(z-15/2)^2. \tag{1}$$

Using cylindrical coordinates the

$$\text{Volume of one Cone}=2\int_0^{\arccos 15} \int_{1/2\sec\theta}^{15/2} zrdrd\theta. \tag{2}$$

$$z=-r+15/2. \tag{3}$$

$$\text{Volume}=192.66 \text{ cu. in.} \tag{4}$$

Using the formula

$$\text{Area}=\tfrac{1}{2}(r^2[\theta-\sin)\theta] \tag{5}$$

for finding the area of a segment of a circle, the volume of the unfilled portion of the cylinder is found to be 5824.80 cu. in.

Vol. of water = Total Volume − unfilled cones − unfilled cylinder.

$$\text{Vol. of water} = 4050\pi + 2\left[\frac{1125}{8}\,\pi\right] - 2(192.66) - 5224.80$$

Vol. of water = 7,402.4 cu. in.

**2210.** *Proposed by William W. Johnson, Cleveland, Ohio.*

Through the sphere $x^2+y^2+z^2=r^2$, planes $x=a$ and $z=b$ are passed. What is the volume cut from the sphere?

*Solution by W. J. Cherry, Berwyn, Illinois*

If $b>\sqrt{r^2-a^2}$, we find the volume of two spherical segments:

$$\pi\int_b^r (r^2-z^2)\,dz+\pi\int_a^r (r^2-x^2)\,dx=\frac{\pi}{3}\,(4r^3-3r^2(a+b)+a^3+b^3)$$

If $b>\sqrt{r^2-a^2}$, the spherical segments have a common part. We must determine the volume of this common part and subtract it from the volume indicated above. Observing the figure, we proceed as follows:

$$V=2\left[\int \frac{1}{2}\,(r^2-z^2)\arctan\frac{\sqrt{r^2-a^2-z^2}}{a}\,dz-\int\frac{1}{2}\,a\sqrt{r^2-a^2-z^2}\,dz\right]_b^{\sqrt{r^2-a^2}}$$

$$=2\left[\frac{1}{2}\,r^2\int\arctan\frac{\sqrt{r^2-a^2-z^2}}{a}\,dz-\frac{1}{2}\int z^2\arctan\frac{\sqrt{r^2-a^2-z^2}}{a}\,dz\right.$$

$$\left.-\frac{1}{2}\,a\int\sqrt{r^2-a^2-z^2}\,dz\right]_b^{\sqrt{r^2-a^2}}$$

$$=2\left[\frac{1}{2}\,r^2\left(z\arctan\frac{\sqrt{r^2-a^2-z^2}}{a}-a\arcsin\frac{z}{\sqrt{r^2-a^2}}-r\arctan\frac{r\sqrt{r^2-a^2-z^2}}{az}\right)\right.$$

$$-\frac{1}{2}\left(\frac{z^3}{3}\arctan\frac{\sqrt{r^2-a^2-z^2}}{a}+\frac{az}{6}\sqrt{r^2-a^2-z^2}+\frac{a^3-3ar^2}{6}\arcsin\frac{z}{\sqrt{r^2-a^2}}\right.$$

$$\left.\left.-\frac{r^3}{3}\arctan\frac{r\sqrt{r^2-a^2-z^2}}{az}\right)-\frac{1}{2}\,a\left(\frac{z}{2}\sqrt{r^2-a^2-z^2}+\frac{r^2-a^2}{2}\arcsin\frac{z}{\sqrt{r^2-a^2}}\right)\right]_b^{\sqrt{r^2-a^2}}$$

$$=2\left[\frac{3r^2z-z^3}{6}\arctan\frac{\sqrt{r^2-a^2-z^2}}{a}+\frac{a^3-3ar^2}{6}\arcsin\frac{z}{\sqrt{r^2-a^2}}\right.$$

$$\left.-\frac{r^3}{3}\arctan\frac{r\sqrt{r^2-a^2-z^2}}{az}-\frac{az}{3}\sqrt{r^2-a^2-z^2}\right]_b^{\sqrt{r^2-a^2}}$$

$$=\frac{a^3-3ar^2}{3}\left(\frac{\pi}{2}-\arcsin\frac{b}{\sqrt{r^2-a^2}}\right)-\frac{3r^2b-b^3}{3}\arctan\frac{\sqrt{r^2-a^2-b^2}}{a}$$

$$+\frac{2r^3}{3}\arctan\frac{r\sqrt{r^2-a^2-z^2}}{ab}+\frac{2ab}{3}\sqrt{r^2-a^2-b^2}.$$

Solutions were also offered by: V. C. Bailey, Evansville, Indiana; Francis L. Miksa, Aurora, Illinois.

**2211.** *Proposed by C. W. Trigg, Los Angeles City College.*

If $\alpha_i$, $\beta_i$, $\gamma_i$ are the distances of the vertices $A_i$, $B_i$, $C_i$ respectively to the points of contact of the incircle with the sides of the triangle $A_iB_iC_i$ having area $\Delta_i$ and if $\alpha_1+\beta_1+\gamma_1=\alpha_2+\beta_2+\gamma_2$ and $\alpha_1\beta_1\gamma_1=\alpha_2\beta_2\gamma_2$, then $\Delta_1=\Delta_2$. Give an example of two such triangles having integral sides.

*Solution by Aaron Buchman, Buffalo, New York*

If the problem is reworded slightly so that $\alpha_i$, $\beta_i$, $\gamma_i$ are taken *specifically* as the distances of the vertices $A_i$, $B_i$, $C_i$ respectively to the points of contact of the incircle with the sides *issued from this vertex*, then the solution is easily accomplished. At once (see *College Geometry* by Altshiller-Court, Par. 118)

$$\alpha_1=s_1-a_1 \qquad \alpha_2=s_2-a_2$$
$$\beta_1=s_1-b_1 \qquad \beta_2=s_2-b_2$$
$$\gamma_1=s_1-c_1 \qquad \gamma_2=s_2-c_2$$

where $s$ is the semi-perimeter, and $a$, $b$, $c$ are the sides of triangle $ABC$. Then

$$\alpha_1+\beta_1+\gamma_1=s_1 \quad \text{and} \quad \alpha_2+\beta_2+\gamma_2=s_2$$

Thus, from the given conditions,

$$s_1(s_1-a_1)(s_1-b_1)(s_1-c_1)=s_2(s_2-a_2)(s_2-b_2)(s_2-c_2)$$

and therefore, $\Delta_1=\Delta_2$

Working backward from the required conditions that two sets of three numbers each, have the same sum and the same product, a set of *sufficient* conditions for the sides of the triangles is easily derived. Thus

$$A_1B_1=p(q+s)+(p-r)(q-s), \qquad A_2B_2=p(q-s)+(p+r)(q+s),$$
$$B_1C_1=q(p+r)+(p-r)(q-s), \qquad B_2C_2=q(p-r)+(p+r)(q+s),$$
$$C_1A_1=p(q+s)+q(p+r), \qquad C_2A_2=p(q-s)+q(p-r)$$

where $p$, $q$, $r$, $s$ are any positive integers such that $p>r$ and $q>s$. For example, for $p=4$, $q=3$, $r=2$, $s=1$, the triangles have the sides 20, 22, 34 and 32, 30, 14. Then $\alpha_1+\beta_1+\gamma_1=\alpha_2+\beta_2+\gamma_2=38$ and $\alpha_1\beta_1\gamma_1=\alpha_2\beta_2\gamma_2=1152$

Solutions were also offered by Francis L. Miksa, Aurora, Illinois; Adrian Struyk, Paterson, New Jersey, and the proposer.

**2212.** *Proposed by Gerald Sabin, University of Tampa.*

A 7 lb. body is attached to a fixed point by an elastic cord 10 feet long. It is released from rest at the support and it falls 14 feet before coming to rest. Find the time taken to make the fall.

*Solution by V. C. Bailey, Evansville, Indiana*

The time required for the body to fall 10 feet is given by the formula

$$s=1/2gt_1^2. \tag{1}$$

That is,

$$t_1=2\sqrt{\frac{5}{g}} \tag{2}$$

The velocity of the body at the end of the free fall is

$$v=\sqrt{2gs}=2\sqrt{5g}. \tag{3}$$

The time required for the body to fall the remaining four feet may be found by finding the time to give a body, starting from rest, the velocity $2\sqrt{5g}$ over a distance of 4 feet.

$$v=\sqrt{2as}=2\sqrt{2a}=2\sqrt{5g}. \tag{4}$$
$$a=5/2g. \tag{5}$$

Then

$$s=1/2at_2^2 \tag{6}$$

$$t_2=\frac{4}{\sqrt{5g}}. \tag{7}$$

$$\text{Total Time } t_1+t_2=\frac{14\sqrt{5g}}{5g}=1.1067 \text{ approximately.}$$

A solution was also offered by the proposer.

**2213.** *Proposed by Alan Wayne, Flushing, New York.*

A one foot square is inscribed in a right triangle whose hypotenuse is 35. Find the other sides of the triangle if its right angle is an angle of the square.

*Solution by Aaron Buchman, Buffalo, New York*

Let one arm of the right triangle be $(m+1)$ and the other arm be $(n+1)$. Since one vertex of the inscribed square coincides with the right angle of the right triangle, the other three vertices of the square are on the two arms and hypotenuse respectively. From the two similar triangles thus formed, it at once follows that

$$mn=1 \tag{1}$$

But

$$(m+1)^2+(n+1)^2=35^2. \tag{2}$$

Expand equation (2), add *twice* equation (1), and regroup terms.
Then

$$(m+n)^2+2(m+n)+1=1226. \tag{3}$$

Take the square root of (3) and transpose the constant.
Thus

$$m+n=-1+\sqrt{1226}=k. \tag{4}$$

Use (1) to replace $n$ in (4) and solve.
Therefore

$$m=\tfrac{1}{2}(k\pm\sqrt{k^2-4}) \tag{5}$$

and

$$n=\tfrac{1}{2}(k\mp\sqrt{k^2-4}). \tag{6}$$

Evaluate $k$ in (4), use this to evaluate $m$ and $n$ in (5) and (6), and add one to each value to obtain the arms of the right triangle. The lengths of the arms are then 1.03 and 34.98 respectively.

Solutions were also offered by: John Q. Taylor King, Austin, Texas; V. C. Bailey, Flushing, New York.

**2214.** *Proposed by Allan Wayne, Flushing, New York.*

Determine the convex quadrilateral having the greatest area and least perimeter if its diagonals are fixed.

*Solution by V. C. Bailey, Evansville, Indiana*

The area of a convex plane quadrilateral, in terms of its diagonals and their angle of intersection, is given by the formula

$$A=1/2ab\cdot\sin\theta. \tag{1}$$

It is apparent from the formula that the area will be greatest when the diagonals are perpendicular. Then

$$A=1/2ab. \tag{2}$$

It can be shown readily that a triangle with a fixed base and a given altitude

has the sum of the other two sides a minimum when the triangle is isosceles.

Therefore, the two diagonals must bisect each other for a minimum perimeter. The required quadrilateral is a rhombus.

## HIGH SCHOOL HONOR ROLL

**The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.**

**Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.**

**For this issue the Honor Roll appears below.**

## PROBLEMS FOR SOLUTION

**2227.** *Proposed by D. L. Foster, Florida A & M College.*

A cask $P$ is filled with 50 gallons of water and a cask $Q$ with 40 gallons of brandy; $x$ gallons are drawn from each cask, mixed and replaced. The same operation is repeated. Find $x$ when there are 9 7/8 gallons in $P$ after the second replacement.

**2228.** *Proposed by D. L. Foster, Florida A & M College.*

Show that the sum of $2n$ terms of the series $1-1/3-1/9+1/27+1/81-1/243-1/729+1/2187$ is

$$3/5\{1-(-1)^n 3^{-2n}\}.$$

**2229.** *Proposed by Roy E. Wild, Palo Alto, California.*

Find all triangles in which the three sides and altitude are of the form $x$, $x+1$, $x+2$, $x+3$, where $x$ is an integer.

**2230.** *Proposed by Max Beberman, Shanks Village, New York.*

In the plane of a given triangle $ABC$ find a point $P$ such that the sum of the distances from $P$ to $A$, $B$ and $C$ is a minimum.

**2231.** *Proposed by W. J. Cherry, Berwyn, Illinois.*

Given three circles whose equations are $x^2+y^2+16x=0$, $x^2+y^2-10x=0$ and $9x^2+9y^2-60x-240y+1600=0$. Find the equations of the circles to which the given equations are tangent (1) externally (2) internally.

**2232.** *Proposed by C. W. Trigg, Los Angeles City College.*

1. What restrictions must be placed upon the sides $b$ and $c$ of a triangle $ABC$ in order that the median to $b$, the join of $C$ to the point of contact of the excircle relative to $C$ with $c$, and the bisector of angle $A$ may be concurrent?
2. Show how to construct such a triangle with ruler and compass.

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Earphone for the television receiver permits individual users to hear a program while watching the pictures without disturbing others in the room. In use, the ordinary speaker is shut off, and the earphones pick up the sound through a control box.

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Ear protector, able to stop loud sudden noises from reaching the ear drum yet admitting conversational tones, fits comfortably into the ear canal. It is a sonic ear valve, without wires or battery, for soldiers, industrial workers and others near explosions.

# BOOKS AND PAMPHLETS RECEIVED

CHEMISTRY VISUALIZED AND APPLIED, by Armand Joseph Courchaine, *Instructor in Biological Chemistry, Hahnemann Medical College, and Science Instructor, Hahnemann Hospital School of Nursing, Philadelphia, Pa.* Cloth. Pages xiv +687. 14×21 cm. 1950. G. P. Putnam's Sons, 2 West 45th Street, New York, N. Y. Price $5.50.

THE WORLD OF NUMBERS, ARITHMETIC 7, by Dale Carpenter, *Supervisor, Mathematics Education Section, Los Angeles City School Districts,* and Elizabeth Cuthbertson, *Teacher of Mathematics, North Hollywood Junior High School, Los Angeles.* Cloth. 332 pages. 14×20.5 cm. 1950. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $1.68.

THE WORLD OF NUMBERS, ARITHMETIC 8, by Dale Carpenter, *Supervisor, Mathematics Education Section, Los Angeles City School Districts,* and George F. Drake, Jr., *Teacher of Mathematics, Van Nuys High School, Los Angeles.* Cloth. 372 pages. 14×20.5 cm. 1950. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $1.68.

EVERYDAY ARITHMETIC, JUNIOR BOOK 1 AND JUNIOR BOOK 2, by Harl R. Douglass, *Director, College of Education, University of Colorado;* Lucien B. Kinney, *Professor of Education, Stanford University;* and Donald W. Lentz, *Principal, Ridge Road School, Parma, Ohio.* Cloth. Book 1, ix+488 pages. Book 2, ix+502 pages. 13×20.5 cm. 1950. Henry Holt and Company, Inc., 257 Fourth Avenue, New York 10, N. Y.

SCÈNES DE LA VIE FRANÇAISE, Revised Edition, by Gilbert Chinard, *Professeur de littérature française à l'Université de Princeton.* Cloth. Pages x+378. 13×20 cm. 1950. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.75.

ELEMENTARY ANALYTICAL CONICS, SECOND EDITION, by J. H. Shackleton Bailey, D.D. Cloth. 378 pages. 12×18.5 cm. 1950. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $1.75.

THEORY OF MENTAL TESTS, by Harold Gulliksen, *Professor of Psychology, Princeton University, Research Adviser, Educational Testing Service, Princeton. New Jersey.* Cloth. Pages xix+486. 14.5×23 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $6.00.

AN AUTOBIOGRAPHY, by Sir Arthur Keith. Cloth. Pages vi+721. 13.5×21.5 cm. 1950. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

QUAKERS IN SCIENCE AND INDUSTRY, by Arthur Raistrick, M.Sc., Ph.D., *Lecturer in Applied Geology (Engineering and Mining) at King's College, Durham University.* Cloth. 361 pages. 13×21.5 cm. 1950. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

ENCYCLOPEDIA ON CATHODE-RAY OSCILLOSCOPES AND THEIR USES, by John F. Rider and Seymour D. Uslan *of the John F. Rider Publishing Company.* Cloth. Pages vii+982. 21×27.5 cm. 1950. John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N. Y. Price $9.00.

ARTHRITIS—AND THE MIRACLE DRUGS, Prepared by Alton L. Blakeslee, *Science Writer for the Associated Press.* Paper. 32 pages. 13.5×21.5 cm. 1950. Public Affairs Committee, Inc., 22 East 38th Street, New York 16, N. Y. Price 20 cents.

TEACHING AIDS, 1950–1951, by Westinghouse Research Laboratories. Paper. 17 pages. 16.5×23 cm. Westinghouse Electric Corporation, 306 Fourth Avenue, P. O. Box 1017, Pittsburgh 30, Pa.

EXTRACLASS ACTIVITIES FOR ALL PUPILS, by Ellsworth Tompkins, *Specialist for Large High Schools.* Bulletin 1950, No. 4. Pages vi+54. 15×23.5 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 20 cents.

HOLDING POWER AND SIZE OF HIGH SCHOOLS, by Walter H. Gaumnitz, *Specialist for Small and Rural High Schools,* and Ellsworth Tompkins, *Specialist for Large High Schools.* Circular No. 322. Pages iv+25. 19.5×26 cm. 1950. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 20 cents.

A MANUAL FOR THE SLIDE RULE, by Paul E. Machovina, *Associate Professor, Department of Engineering Drawing, The Ohio State University.* Paper. 15×22.5 cm. 1950. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price 75 cents.

INTRODUCTION TO TESTING AND THE USE OF TEST RESULTS, by Margaret Selover, Agatha Townsend, Robert Jacobs and Arthur E. Traxler. Educational Records Bulletin, No. 55. Pages vii+107. 20.5×28 cm. August 1950. Educational Records Bureau, 21 Audubon Avenue, New York 32, N. Y.

SURVIVAL UNDER ATOMIC ATTACK. Executive Office of the President National Security Board Civil Defense Office. NSRB Doc. 130. 31 pages. 13×19.5 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 10 cents.

SPINNO, AN ARITHMETIC NUMBER GAME, Designed by Elda Merton. The John C. Winston Company, 1010 Arch Street, Philadelphia, Pa. Price $2.00.

NUCLEAR PHYSICS CHARTS. 25×37 inches. School Service, Westinghouse Electric Corp., 306 Fourth Avenue, P. O. Box 1017, Pittsburgh 30, Pa. Per Set of Six Charts $1.00. A Supplement to the Charts on Nuclear Physics. Price 10 cents.

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## COLOR OF SUNLIGHT VARIES AS MUCH AS 50 PER CENT

During the year natural daylight varies 50 per cent in its color, due to variation in the altitude of the sun, members of the Photographic Society of America were told at their national convention in Baltimore.

Effect of the sun's altitude on daylight was discussed in a technical paper by R. H. Bingham and Dr. Herman Hoerlin, research scientists at Ansco Research Laboratories, Binghamton, N. Y.

The changing color of daylight, an important factor to all outdoor color photographers, was studied to determine the effects on the individual layers of color film. Results of the project showed a very close relationship between the color of light and the angle of the sun above the horizon.

In their experiments, the Ansco scientists made photographs of a gray scale under natural daylight illumination at various times of day and for different months of the year. These photographs were processed together with sensitometric strips which had been exposed to a standard artificial daylight source.

Expressing the experimentally measured color variations in terms of their effect on color film, it was found that during the year natural, sunny daylight varies 50 per cent in its blue content relative to red content, due to variations in the altitude of the sun.

Observations for the project were made in Binghamton, Chicago, Dallas and San Diego. Nearly the same color range was found to hold for all four cities studied.

The color change was found to be equivalent to a temperature change from 5,300 K to 6,500 K.

# BOOK REVIEWS

PHYSICS: FUNDAMENTAL PRINCIPLES FOR STUDENTS OF SCIENCE AND ENGINEERING, by George Shortly, B.E.E., Ph.D., *Professor of Physics, The Ohio State University*, and Dudley Williams, A.D., Ph.D., *Associate Professor of Physics, The Ohio State University*. Cloth. Volume I, pages xii+471+x. Volume II, pages xii+797. 15×23 cm. 1950. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price, Volume I, $4.50, Volume II, $5.50.

This two volume course of 1271 pages was written for students fully prepared for a course in science or engineering physics. A year of high school physics, a year of college chemistry, and a year of college mathematics are prerequisite and the student should have had or should carry the course in calculus along with the physics. Trigonometry and analytics are used in the first chapter and integration before the student has covered 100 pages. At no place is the student left in doubt. All new terms are carefully explained and definitions are given accurately and discussed. Often the meaning is clarified by diagrams. Each diagram has a definite purpose; no pictures are used in Volume I just to illustrate or add interest; the pupil is assumed to be taking the course because he already is interested in its content and expects to use it later in his daily work. The two systems of units absolute and gravitational, are clearly explained. Especially for the engineering student the pound of force and the slug of mass are discussed. The poundal is explained but no further use is made of it throughout the text. The value of problems as an aid to mastery of principles is used skillfully. Two or three pages of explanation are followed by a good list of 10 to 20 problems applying the principles just discussed; or in some cases, as the topic on linear momentum, eight problems follow immediately, and the topic on impulse is followed by four problems.

In the first volume 314 pages are given to the treatment of mechanics and 139 pages to heat. Physical and mathematical data and tables occupy 17 additional pages. In the second volume 95 pages are given to wave motion and sound, 210 pages to light, 310 pages to electricity and magnetism, and 118 pages to modern physics. In this volume there is also an appendix which gives a good discussion of systems of electrical and magnetic units, tables of physical constants, properties of elements, conversion factors, and other important constants, and a set of mathematical tables.

The second volume follows the same general plan of presentation as the first but use of photographs such as diffraction patterns, use of polaroid filters, cloud chambers, the linear accelerator, betatron, and other relatively new physics illustrations are given. The new photometric standards developed by the Bureau of Standards and adopted by the International Committee on Weights and Measures are used throughout the sections on photometry. In electricity electrical networks and the use of Kirchhoff laws in their solution are well discussed and illustrated by problems for solution. Circuit elements containing inductance, capacitance, and resistance are thoroughly treated and power in such circuits fully explained. At rare intervals one finds a section starred which "may be omitted without loss of continuity" but these sections add up to a very small part of the entire course. A few minor errors occur but they are either easily detected or are not very important, e.g. on page 126 is found "the pound . . . is defined as 453.5924277 kg" and on page 685 the photograph of Newton's rings is credited to Jemima B. Dutcher instead of to John B. Dutcher. Our sincere congratulations to the authors on the production of such an excellent text.

G. W. W.

ALGEBRA, BOOK TWO, SECOND COURSE COMPLETE, by A. M. Welchons and W. R. Krickenberger, *The Arsenal Technical High School, Indianapolis, Indiana*. Cloth. Pages x+516. 14×20.5 cm. 1949. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.20.

This book covers the usual subject material for a second course in high school algebra. It differs from the run of the mill texts in manner of presentation, printing, layout, and supplementary material of historical and scientific nature.

The opening pages take the reader immediately into the confidence of the authors. A preface in outline form with space between paragraphs attracts the eye; what is said holds the attention and makes one read on. The purpose and what has been done to accomplish it is clearly stated, and the student may follow the text more intelligently for viewing the techniques employed to gain those desirable ends.

Following this and opposite the table of contents is a list of suggestions on how to study, introduced with the friendly hope that the study will be both successful and enjoyable. The recommendations are definite, standard practices which, teachers must remember, are not as familiar to the student as they are to graduates of a course in Education. It is well not to take for granted that a junior or senior in high school does know how to study, and certainly it is not out of place to give a nod in that direction to anyone undertaking the course in advanced algebra.

Off to a good start, the book itself deals adequately with topics found in modern algebras. What distinguishes it is the way it is written, both as to wording and printing. It is extremely legible. Paper has not been spared and the eye is relieved by wide margins and open space within the context. Two kinds of heavy type as well as italics serve to highlight statements of importance, and the effect is further enhanced by boxing clearly stated rules.

Not only is the book legible as to format, but it is also readable in style. A conversational tone creeps into the introductions and development of topics. "Solve the equation for $y$, unless it is easier to solve for $x$." One has a feeling that the authors are teachers as well as textbook writers, and that they are familiar with the difficulties of the student that are not always mathematical in nature. Occasionally a comment on a use familiar in daily experience or perhaps some historical connection is woven into the discussion. These are further emphasized by separate pages of pictures as modern as an atom smasher, as informative as a diagram of a three-tube receiver, as pertinent to a student's needs as an honest statement of "How much college mathematics is needed in the study of medicine."

The first chapters review elementary algebra integrated with advanced work. Subsequent chapters develop the subject. A chapter on elementary trigonometry occurs half way through, then algebraic work is resumed. The last chapter anticipates the calculus, introducing the idea of a first derivative by the delta method but without going into the theory of limits. The applications of rate of change and slope are made. This in a way epitomizes the point of view of the authors throughout the book: one of stressing applications and skills without much recognition of whence they came.

The articles and exercises are designated in such a way that the book may be used for a minimum, a medium, or a maximum course. There are lists of problems, many diagrams, review tests, vocabulary summaries. No answers are provided for the student. Tables of square roots, logarithms, trigonometric functions and their logarithms are included.

This review cannot cover all the material found in the 516 pages. If it convinces the teacher who is looking for a new book that this is one worth considering, it will have served its purpose.

ALICE N. TUCKER
*J. S. Morton High School and Junior College*

THE PHILOSOPHY OF MATHEMATICS, by Edward A. Mazairz, C.PP.S., M.S., Ph.D., *Saint Joseph's College, Collegeville, Indiana.* Cloth. Pages viii+286. 13.5×21.5 cm. 1950. The Philosophical Library, Inc., 15 East 40th Street, New York 11, N. Y. Price $4.00.

This book was, according to the preface, originally submitted as a doctoral thesis at the University of Ottawa. To many readers, it will characterize their concept of a doctoral thesis, dry reading, many footnotes, an extensive bibliography. It cannot be denied that the material does not read like a detective story, nor that there are many notes. (There are 88 pages filled with footnote references, and 857 such footnotes.) However, one interested in the development, particularly the historical development, of the philosophy of mathematics will find this book a distinct contribution.

The book has an introductory chapter which attempts to state the problem of the philosophy of mathematics. From that point, although there are two parts, the treatment is largely historical. For example, the meaning of the philosophy and contributions of such as Plato, Aristotle, Descartes, Spinoza, Lebnitz, Newton, Berkeley, Kant, and others, is discussed.

Whether or not one agrees with the conclusions of the author at any point, it cannot be denied that a great deal of research and effort must have been necessary to produce this work. Both mathematicians and philosophers may be interested; the reviewer cannot concur that the general cultural reader will welcome this book, so to speak, with open arms.

CECIL B. REED
*University of Wichita*

GEOMETRY FOR ADVANCED PUPILS, by E. A. Maxwell, *Fellow of Queens' College, Cambridge.* Cloth, 176 pages. 13.5×21.5 cm. 1949. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $2.25.

Although there may be a few places where this book would be suitable for a text, these would definitely be the rare exception, rather than the rule. Probably the greatest value would be in one of two possible uses: Supplementary reading for the teacher who wishes to go a little beyond the material of the usual high school course in plane geometry (whether or not a formal course in college geometry, teaching of geometry, or projective geometry has been taken); and for the school library for reference and as a challenge to the superior student.

The background required is no more than that of high school geometry, and a considerable portion of the material would not require the complete course usually taught. The book is divided into three parts, the first is to some extent purely informative and recreational. In the second portion one meets some of the concepts of classical projective geometry while in the third there are presented many properties of circles which could be with little change extended to conic sections. (From the point of view of the student interested in plane geometry, the author has made a wise choice in limiting the discussion to circles.)

Some representative topics will indicate the scope of the work: Nine-Point Circle; incentre and escribed centres; the Pythagoras figure (many properties are presented which are not commonly known); incentre and circumcircle; Simson line; Desargues configuration; the line at infinity; harmonic range; theorems of Menelaus and Ceva; theorem of Apollonius. There is a collection of 63 exercises, some relatively simple, others will present more difficulty.

This book is very strongly recommended both for the teacher's personal library and for the high school or teacher's college library. At almost every page one finds suggestions for mathematics club programs.

CECIL B. READ

THE CARUS MATHEMATICAL MONOGRAPHS, NUMBER NINE. THE THEORY OF ALGEBRAIC NUMBERS, by Harry Pollard, *Cornell University.* Cloth. Pages xii+143. 12.5×19 cm. 1950. Published by the Mathematical Association of America, Buffalo 14, N. Y. Price $3.00.

This is number nine in the Carus Mathematical Monographs, sponsored by the Mathematical Association of America. These are in general expository presentations of a particular field or topic in mathematics, and are not usually planned

for a text, although some might be so used.

There would seem to be no formal mathematical background needed to read this book beyond fairly elementary determinant theory and analytic geometry. The treatment, however, is rigorous, and at times somewhat condensed; as a result a considerable amount of mathematical maturity would be very helpful. Because of both terminology and notation which may be new to the reader, it is difficult to follow the discussion of a single topic without reading much of the preceding material. To state this another way, the work would seem to be of greatest value when studied in its entirety. The summarization of the book makes available in one place much material not heretofore readily available. An eleven item bibliography is included. The index, although on a single page, seems to be reasonably complete.

In common with the preceding monographs, the work bears the distinct appearance of authoritative writing. It should of course be on the shelves of every university library, it probably does not belong in any high school library. The question of its purchase for a college library would of course depend on the character of the work given and the question of whether the library is solely for undergraduates or whether it is also for the benefit of the faculty.

CECIL B. READ

THE CARUS MATHEMATICAL MONOGRAPHS, NUMBER TEN. THE ARITHMETIC THEORY OF QUADRATIC FORMS, by Burton W. Jones, *University of Colorado*. Cloth. Pages x+212. 12.5×19 cm. 1950. Published by the Mathematical Association of America, Buffalo 14, N. Y. Price $3.00.

This is number ten in the series of expository presentations sponsored by the Mathematical Association of America, known as the Carus Mathematical Monographs. Although such monographs are not usually written as texts, they might in some cases be so used. This particular book has at the end a collection of almost 100 problems, which might be of value if the book is used as a text or as supplementary material in a course.

The author assumes knowledge of number theory and of the theory of matrices is possessed by the reader. He states in the preface that some results and methods appear in this book for the first time. The treatment is definitely not in the classical order of development, rather the reverse seems to be true—presentation of the general case first, later applying to restricted cases. The theory presented may well be said to be complete in this book.

The book has both a general index and an index of theorems—a feature which other authors might well copy. Unfortunately the general index is not always complete. For example, the reviewer wished to comment favorably on the fact that the author pointed out discrepancies in usage of the term "determinant" or "discriminant" as applied to a binary form. Reference to the word *discriminant* failed to locate this word in the index; the references to the word *determinant* and to the term *binary form* failed to mention page 139, although it is on that page that the definition of the determinant of a binary form is emphasized.

The minor criticism about the index in no way detracts from the general excellence of the book. It is up to the high standard of previous monographs in the series, and should prove a very valuable source of information not previously available in a single small volume. There is a fifteen item bibliography.

CECIL B. READ

MECHANICS VIA THE CALCULUS, by P. W. Norris, M.A., B.Sc., F.R.S.A.; *Sometime Senior Mathematical Master, Alleyn's School, Dulwich*, and W. Seymour Legge, B.Sc.; *Sometime Senior Lecturer in Mathematics, The Polytechnic, London*. Third Edition, revised and enlarged. Pages xii+372; 195 diagrams. London: Cleaver-Hume Press Ltd. New York: Dover Publications Inc. Price $3.95.

This book had its first edition more than 25 years ago. It is neither a *formal* textbook (in either Analytical Mechanics or the Calculus), nor a *problem* book in

the usual sense. It is, in my judgment, the best of both of these. It treats the standard subject matter of Mechanics (Statics, Dynamics of a Particle, Rigid Dynamics, and Hydrostatics) through *brief* but excellent exposition followed by extensive illustrative problems. These problems are both general and particular; the former being algebraic possess powerful advantages. They permit "dimensional check" and more important still, a consideration of limiting cases as logical extremes. These features are extremely important and are lost altogether when numerical data are used. On this point it should be remarked that American students by and large do not like this algebraic representation; they like numbers instead of algebraic symbols!

Both the Mechanics and the Calculus proceed from the elementary to the complex. The illustrative problems are elegantly done and the problems for student solution cannot be excelled in quality. The intent of the book, as the authors put it, is "that this textbook will serve to bridge the gap which we feel exists between the elementary textbooks on the subject and the complete treatises . . . ." It does this admirably and more. When I next give a course in Analytical Mechanics to upperclassmen or beginning graduate students I will use this book. It has just enough discourse on principles to take the student at once to the heart of the matter and it simultaneously gives the teacher latitude to add to the discussion as he wishes. And if he doesn't there's enough here for the able student to get it himself.

I cannot help saying again that the problems for solution are very beautiful! They remind one of the elegant classic recitation of Jeans, say, where a spider climbs a web, or meteoric dust accumulates on the earth's surface and alters the day!

I was once told by a mathematics professor in good standing that he felt that mathematics students learn more calculus in analytical mechanics than they do in their calculus. I am sure of this. And this book will enhance their achievement in both quarters.

There are a host of worked illustrative problems and over 500 for the student to do. To these the answers are given. Many of these are so exciting and attractive that I find myself doing them recreationally!

JULIUS SUMNER MILLER
*Dillard University*
*New Orleans, Louisiana*

ELECTROMAGNETIC THEORY, by Oliver Heaviside. Complete and Unabridged Edition of Volume I, Volume II, and Volume III with a Critical and Historical Introduction by Ernst Weber, *Director, Microwave Research Institute, Polytechnic Institute of Brooklyn*. 9×12. 386 pages. Dover Publications, Inc., New York. Price $7.50.

This year (1950) is the centennial anniversary of Heaviside's birth. It is most timely, therefore, that his classic *Electromagnetic Theory* be made available afresh. The work was originally published in 3 volumes, some 1,500 pages, between 1891 and 1912. This new format and special pagination puts the entire treatise in one volume at moderate price without condensation or deletion.

*This book cannot be reviewed! Who can "review" Heaviside?* All we can do, all we need do, is say a few things about *this* edition, and a few general comments on Heaviside in general.

This is Heaviside's masterpiece. The detail of his discussion is extraordinary; the extent overwhelming. Added to this is his genius for flavoring his exposition with remarks most unorthodox. His personality is alive on every page. "It would appear that Prof. Tait, being unable to bring his massive intellect to understand my vectors, . . . has delegated to Prof. Knott the task of examining them, apparently just upon the remote chance that there might possibly be something in them that was not utterly despicable." Or again: "Prof. Perry has asked me to write something in criticism. . . . What is the use? He knows my views pretty well, and others too; and those who don't can learn them if they want to by buy-

ing my books. That is the best way, as it brings in one-and-threepences, and so does some good."

His very last page is more exciting still. Entitled *"Limitations on Scientific Prediction"* it attests to his phenomenal intellect. "All known disturbances are conveyed either electromagnetically or gravitationally." (This 40 years ago!) "Large amounts of energy may be very condensed by reason of great forces at small distances."

The critical and historical introduction by Ernst Weber is beautifully done, considering the task. He cites too, a choice bibliography.

The publishers render a valuable service in making this volume available *at this price.*

JULIUS SUMNER MILLER

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## AUTHOR REPLIES TO A BOOK REVIEW

In the October 1950 number of this magazine, there appeared a review of the Sixth Edition of my *Progressive Problems in Physics.* Several of the points made by the reviewer seem to be not well taken and even contrary to fact.

(1) He says, for example, that very few of the problems "involve any cerebration," and that most of them "lend themselves at once to mere formula substitution." Of course most numerical problems in physics can be worked by formula, but that fact should not be charged against this book as a defect. This book, as well as any book, can be misused, and certainly one kind of misuse would be allowing or encouraging the immediate use of formulas in solving problems. The problems are devised and arranged so that they may be used to lead the student to analyze more and more complex problems. Whether or not the student is supplied with or led to develop formulas is not prescribed by the author.

(2) The author does not claim in the Preface that the principles of physics could be taught from this book alone (as the reviewer says he does), but he does claim that the first few problems in any group can be used to teach the topic of that group. As a sample, see problems 417–422.

(3) The reviewer criticizes the book because no answers are supplied. There is an answer book, and it is furnished to teachers, but the fact is not mentioned in the text because many teachers do not wish their pupils to know of it. The author, however, believes in giving out the answers and always posts them on the bulletin board with the home lesson assignment. Answer books could be purchased for the students if the teacher so requested.

(4) Concerning Tables and Physical Constants the reviewer says, "It is my firm conviction that elementary students should not be burdened with this terrific confusion of conversion." This is true. They should not be. And that is the reason for the tables in the Appendix of this book. They are for reference only and are not to be learned. Furthermore it makes for simplicity in the wording of the problems if the constants are not given in each problem but can be looked up in the tables. In the larger high schools the science teacher undoubtedly owns a Handbook of Physics and Chemistry, but it is hardly to be expected that many of the students will own them. In many of the smaller schools the teacher is not primarily a physics teacher, and so does not own a science library. Such teachers need all the help the book can give.

As to the metric system, in many schools the metric system is given scant or no attention in arithmetic and general science courses, yet it is used from the very start in physics. A page is put into the Appendix and there are several problems in the Supplementary Section for the benefit of those teachers who may not wish to approach the metric-English conversions through the "1 inch = 2.54 centimeters and 1 kilogram = 2.20 pounds" equivalents only.

This Supplementary Section contains also problems in long division, square roots, and areas and volumes for those teachers who find their pupils weak in those lines.

The reviewer is generous enough to admit he may be "wrong" in his criticism since the book is now in its sixth edition. To the writer it seems probable that no right or wrong appellation should be used in connection with his review. On the other hand there are, as the reviewer suggests, different points of view, as the sales record over a period of forty years and the use of the book in preparing many students for entrance into our best technical colleges testify.

FRED R. MILLER
*Author Progressive Problems in Physics*

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## NOMINATIONS FOR THE JAMES FLACK NORRIS AWARD FOR OUTSTANDING ACHIEVEMENT IN THE TEACHING OF CHEMISTRY

The Board of Directors of the Northeastern Section of the American Chemical Society have voted to call for nominations so that the first grant of the James Flack Norris Award may be made at the meeting of the Section on May 10, 1951. Nominations, accompanied by ample supporting evidence of the achievements of the nominee, should be sent to any one of the members of the following Canvassing Committee:

Ernest C. Crocker, Chairman of the Arthur D. Little Company, Cambridge, Massachusetts
Hubert N. Alyea, of Princeton University, Princeton, New Jersey
Samuel T. Arnold, Brown University, Providence, Rhode Island
Paul D. Bartlett, Howard University, Cambridge, Mass.
James A. Campbell, Oberlin College, Oberlin, Ohio
Helen W. Crawley, Walnut Hill School, Natick, Mass.
Edwin R. Gilliland, Massachusetts Institute of Technology, Cambridge, Massachusetts
Harold A. Iddles, University of New Hampshire, Durham, New Hampshire
John A Timm, Simmons College, Boston, Massachusetts

The nominations, which should be submitted before the end of 1950, will be transmitted by the Canvassing Committee to the Award Committee, whose personnel is kept secret.

The James Flack Norris Award shall be made for outstanding achievement in the teaching of chemistry, particularly when demonstrated at college and secondary school levels rather than shown in the direction of research. The award is given in memory of the late James F. Norris in accordance with the wishes of the late Mrs. Anne C. Norris who left a substantial bequest to the Northeastern Section to be used to perpetuate the memory of her husband.

Professor Norris was a student of Ira Remson, one of chemistry's greatest teachers. He gained his outstanding reputation as a chemistry teacher at Harvard and Clarke Universities, as Professor at Vanderbilt University and Simmons College, and at the Massachusetts Institute of Technology where he became Director of the Research Laboratory of Organic Chemistry. He was chairman of the Northeastern Section, was twice President of the American Chemical Society and served on its Board of Directors for eleven years. He was also interested in the applications of chemistry to industry and served frequently as an industrial consultant.

The award comprises both a sum of money and a scroll suitably engrossed with an appropriate citation. It is the intention of the Northeastern Section to give this award biennially in years alternate with the Richards Medal for achievement in research.

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Fluorescent "bulb" can be screwed into the ordinary electric outlet in place of an incandescent bulb and projects only about six inches from the socket. It contains two lamp tubes within a box-like shade and gives up to 500 footcandles of light at a four-foot working distance.